THE ASSOCIATION BETWEEN POST-WEANING DIETARY PATTERNS AT AGE 1 AND GROWTH AT AGE 2, FROM THE BIRTH-TO-TWENTY COHORT STUDY, SOUTH AFRICA

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DECLARATION

I, Tabither Muthoni Gitau hereby declare that this research report is my own unaided work. It is being submitted for the degree of Masters of Science (Medicine) in the field of Epidemiology and Biostatistics at the University of Witwatersrand, Johannesburg. It has not been submitted entirely or partially for any degree or examination at this or any other University.

Signature

Date

DEDICATION

I wish to dedicate this research report to my adorable parents Gabriel Muchuku Gitau (dad), Jane Waithera Gitau (mum) and my loving siblings Benjamin Mbugua, Peris Wangui and Robinson Muchuku for their endurance, love and support they gave me during my one year study period at the University of Witwatersrand in Johannesburg, South Africa.

ABSTRACT

Introduction Malnutrition remains the major cause of child mortality and an essential component in child development and future productivity of the child in the world. With the increasing prevalence of undernutrition, micronutrient deficiencies, and over nutrition in South Africa, it calls for interventions which will help reduce malnutrition since child's growth is partly dependant on their diet. This study aimed at determining the association between post-weaning dietary patterns at age one and growth at age two among children from the Birth-To-Twenty cohort in Johannesburg, South Africa.

Specific objectives: To describe dietary intake patterns (Diet Diversity Score and Food Variety Score) growth at age one and two among boys and girls in BT20, the prevalence of malnutrition (Stunting, wasting and underweight) among boys and girls in BT20, and to determine the association between dietary patterns at age one and growth at age two. **Hypothesis** There is no association between post-weaning dietary patterns at age one and growth at age two in the Birth-To-Twenty Cohort study. **Study design:** Prospective longitudinal study. **Setting;** Birth-To-Twenty Cohort study Johannesburg, South Africa. **Inclusion criteria** –Must have complete data on dietary questionnaires and growth data at age two. **Data Collection** data was collected on following variables; dietary patterns, socio-economic status, growth (height and weight), complimentary feeding, birthweight and gestational age. Anthropometric data (height and weight) was collected at age one and two. Food frequencies questionnaires were used for data collection. **Data Analysis** STATA 10 was used for data cleaning and analysis. Descriptive and inferential analysis was carried out. Multiple regression analysis was used to assess the association between outcome variable (growth at age 2) and dietary patterns at age 1(12months) and growth at age 2 (24months), and dietary patterns at age 1 controlling for confounders. P-values were calculated to test for

statistical significance at 5% significance level. **Results**: Ninety six percent of the infants were introduced to solid foods when they were less than 6 months. The Food Variety Score (FVS) was 32.4 and 32.6 for boys and girls respectively; Diet Diversity Score (DDS) was 9.7 and 9.8 for boys and girls respectively. A proportion of 20.5% (n=164) infants were underweight at birth, the prevalence of stunting among the boys rose from 8% at year one to 19% at year two, wasting demonstrated a slight increase from 5% to 8%, underweight too showed a sharp increase from 11% to 25%. Among the girls stunting prevalence increased from 6% at year one to 20% at year 2, wasting slightly rose from 3% to 4% and underweight from 6% to 11%. There was 7.7% (n=35) catch up growth and 20.7% (n=94) catch down with regard to stunting. A proportion of 3.3% (n=15) infants had catch up for weight-for-height and 5.5% (n=25) had a catch down growth. 3.7% (n=17) had catch up growth with regard to weight-for- age and 11.2% (n=51) had catch down growth. Birthweight, underweight and stunting at age one, gender and ethnicity were associated with growth at age two. There was no association between dietary patterns at age one and growth at age two. **Conclusion**: Diet diversity is good within Soweto and consequently food diversity is not associated with infant growth, however other factors such as macronutrient intake and morbidity maybe important in the Soweto context. Inappropriate feeding practices such as feeding the infant with high sugar diet, high fat and refined foods should be addressed so as to curb the increasing catch down growth at age two. Introduction of solid foods at less than 6 months of age should also be addressed; this can be done by emphasising that exclusive breastfeeding in community health programs for the first 6months.

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KEY WORDS

Food Variety Score (FVS) is the number of different food items eaten during a one week period.[1]

Diet Diversity Score (DDS) is the number of food groups consumed over a period of one week by each child. [2]

Wasting: (weight-for-height) is a condition in which a child's weight for height falls below minus two standard deviation from the median of the standard reference population.

Stunting: (height-for-age) is a condition in which a child's height for age falls below minus two standard deviation from the median of the standard reference population.

Underweight: (weight-for-age) condition in which a child's weight for age falls below minus two standard deviation from the median of the standard reference population.

Z-score: the deviation of an individual's value from the median value of a reference population, divided by the standard deviation of the reference population.

Catch up (Catch down) growth: shows an increased (decreased) growth velocity in height, weight and weight-for-height when there is an addition (removal) of some constraints on normal growth.

[1] WHO has no standard reference values for Food variety Scores

[2] WHO has no standard reference values for Diet diversity Scores

ACRONOMYNS

Bt10: Birth-To-Ten Cohort study

Bt20: Birth-To-Twenty Cohort study

FVS: Food Variety Score

DDS: Dietary Diversity Score

FFQ: Food Frequency Questionnaires

SFFQ: Semi-quantified Food Frequency Questionnaire

OR: Odds Ratio

95% CI: 95% Confidence Interval

SAVACG: South Africa Vitamin A Consultative Group

WHO: World Health Organisation

UNICEF: United Nations Children's Fund

WFP: World Food Programme

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

An excellent global indicator of measuring child's wellness is growth. In developing countries poor child growth is as a result of many factors such as poverty, poor maternal education, increased morbidity, and inadequate nutritional intake for both the mother and the child these increases the chances of low Birthweight and poor growth curves[1] [2]. Assessing a child's growth serves as a means of evaluating the health and nutritional status of children and also a vital method in measuring inequalities in human development experienced by different populations[3].

One of the Millennium Development Goals (MDG) targets hunger and poverty, it aims at halving the proportion of people who suffer from hunger between 1990 and 2015 and one of the key indicators used to monitor progress for this target is the proportion of children who are underweight[4, 5].

Nutritional deficiency and malnutrition in developing countries are substantially increasing; approximately 800-1000 million of the world's population are affected by Protein-Energy Malnutrition (PEM) and approximately 15 million deaths occur each year as a result of malnutrition. Poverty and poor infant nutrition have proved to be significant causes of poor child growth [6].

An estimate of 55million children are wasted, of whom 19 million children are affected by severe acute malnutrition globally. In 2005, 20% of children younger than 5 years of age in low and middle-income countries were underweight. The prevalence's were highest in South-central Asia and Eastern Africa where 33% and 28%, respectively were underweight with 74 million of them being stunted. Africa has approximately 35% and Sub-Saharan Africa 42% of

children under the age of 5 year who are stunted. In the Sub-Saharan countries it is estimated that malnutrition underlies more than half of all infants and children mortality [5, 7]. An estimated 32% of children younger than 5 years of age in low and middle-income countries were stunted. Eastern and middle Africa has the highest prevalence estimates where 50% and 42%, respectively were stunted. There are 61 million stunted children in India, which is over half (51%) of all Indian children under age 5 years, and 34% of all stunted children worldwide [5].

According to the South African National Food Consumption Survey (NFCS, 1999) of children aged 1-9years, 10.3% were underweight, 21.6% were stunted and 6% were overweight [7, 8].

1.1.1 PROBLEM STATEMENT

Undernutrition is a major cause of child mortality, and also a vital component in child development, maternal health and adult productivity [5]. In South Africa approximately 2.3 million children suffer from undernutrition [9], 21-48% of the children are stunted, 8-15% are underweight whereas 3.7% are wasted. Though rural areas in South Africa have higher levels of undernutrition, 17% of children living in urban areas are undernourished. Children living in informal urban areas are more highly affected compared to those who live in formal urban areas: 20% and 17% respectively [7, 10-12].

It has been shown that infants who are undernourished by the time they reach their second birthday may develop irreversible physical and cognitive damage. This may impact on the child's future health and economic wellbeing. The effects of malnutrition will continue into adulthood and may be passed to the next generation [5].

1.1.2 JUSTIFICATION

It is important to focus on malnutrition in children since it is an indicator to measure progress towards the Millennium Development Goal. A number of studies have been undertaken but there are no well documented studies looking at the association between dietary feeding patterns at year one and growth at year two. Many studies have focussed on nutrition e.g. energy and macronutrient intake at two interceptions during 2000 and 2003 [13] , but none has focussed on investigating the association between feeding patterns and growth at age two. With the increasing prevalence of undernutrition, micronutrient deficiencies and over nutrition in South Africa, it calls for interventions which will help reduce malnutrition since child's growth is directly dependant on their diet [11].

Studies have shown that undernutrition at age two results in irreversible physical and cognitive development and also impacts on adult outcomes such as lowered human capital, lowered academic achievements and children becoming short at adulthood [14] .Hence this

study intends to utilise the dietary intake patterns, in particular food diversity, growth data at age one and growth data at age two as collected by the Birth to Twenty (Bt20) study so that the association between post-weaning dietary patterns and child growth can be investigated, and it is hoped that the study outcomes will help contribute to future interventions.

1.1.3 AIM OF THE STUDY

To determine the association between post-weaning dietary patterns of children at age one (12months) and growth at age two from the Birth-To-Twenty Cohort study.

1.1.4 RESEARCH QUESTION

Is there an association between post-weaning dietary patterns at year one and growth at year two?

1.2 LITERATURE REVIEW

1.2.1 ASSOCIATION BETWEEN MALNUTRITION AND CHILD GROWTH

Child's growth is the most widely used indicator of nutritional status and it is internationally recognised as an important public health indicator for monitoring health in populations[(1)]. Stunting and wasting are important health concerns for children living in environments with poverty, poor nutrition and high prevalence of infectious diseases. The key stages in a child's life (1-5 years) are the prenatal period and the first two years after birth. At these stages, rapid growth can takes place, while on the other hand any nutritional and psychological deficiency experienced will have a permanent effect for the rest of the child's life[(6)]. The first few years of life are very important because both physical and mental development take place; hence any damage suffered in early life leads to permanent impairment and might also affect future generations. Its prevention brings about important health, educational, and economic benefits [(14, 15)]. Various studies have proven that there is an association between increasing severity of

anthropometric deficit and infant mortality. Poor infant growth is also highly associated with delayed mental and intellectual achievement which in turn affects school performance and also impairing adult productivity hence affecting economic productivity [3, 15]. Height-for-Age (stunting) an indicator of long term malnutrition, Weight-for-Age (underweight) an indicator of acute malnutrition which is short term and weight for height (wasting). Stunting shows a failure of attaining a linear growth which may be as a result of poor health or nutritional deficiencies; underweight reflects both the child's height and age faltering whereas wasting reveals any unusual low body tissue and fat mass of an individual of that height[1, 16].

1.2.1.1 FACTORS ASSOCIATED WITH INFANT GROWTH

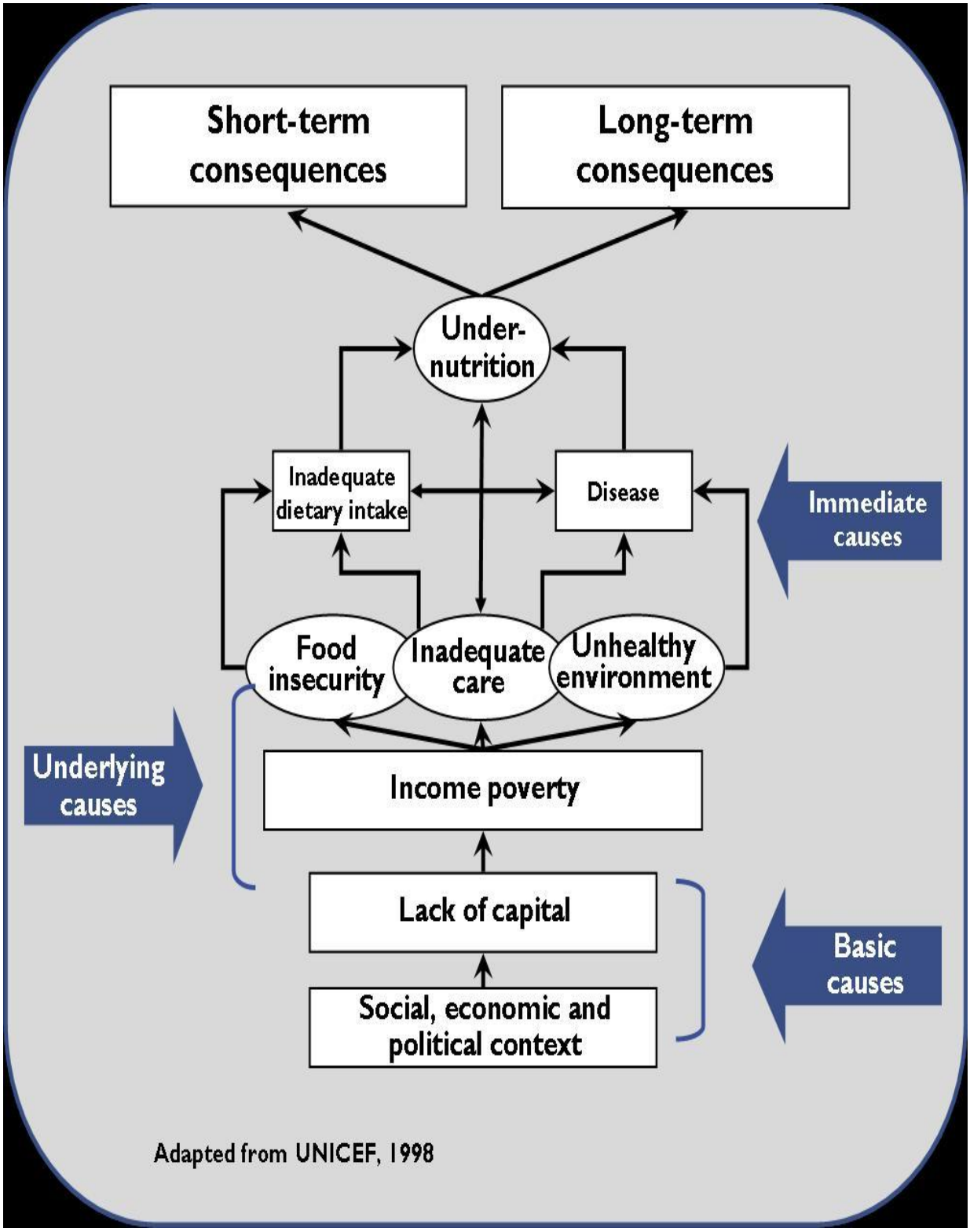
Figure 1 explains the complexity of malnutrition which is divided into three main levels namely immediate, underlying and basic causes.

Immediate causes involve the two main causes of malnutrition at individual level i.e. inadequate dietary intake and child illness, inadequate nutrients intake lowers the body immunity this leads to decrease in ability to resist infections which results to loss of appetite, malabsorption and metabolic changes.

Underlying causes Inadequate access to food at household level, inadequate access to health services and inadequate care for children and mothers, all lead to occurrence of the child illness and inadequate dietary intake (immediate causes).

Basic causes e.g. lack of knowledge, political factors, cultural and religious and economical difference results to inadequate utilization of already available resources which in turn leads to the occurrence of the above two factors. This is elaborated in figure 1.

Figure 1: Factors that lead to child malnutrition



Association between maternal education and growth

Inadequate maternal knowledge on nutritious infant foods and incorrect feeding practices is a major determinant of malnutrition compared to lack of food, to address infant malnutrition in South Africa, strategies on correcting inappropriate feeding practices must be set right[17]. Some of the mothers using formulas for infant feeding suffer from illiteracy, innumeracy and language barriers hence they end up using incorrect measurement, this results to inadequate energy density for the infants[18].

Association between socioeconomic status and infant growth

In most developing countries malnutrition was highly associated with the poorest quintile of socioeconomic status[19]. It has been proven that the South African setting is ideal for assessing the socio-economic status differences in child growth and health outcomes because of the wide range of inequality in incomes and the apartheid history which shows a strong correlation between ethnicity, socio-economic status and health outcomes. Socio-economic status is associated with various diseases that greatly affect birth outcomes, malnutrition, stunting and child growth[20].

Stunting and underweight are sensitive to improvements in the socioeconomic status of the household, unlike wasting[19]. Children from poor households have high rates of underweight and stunting which are 3 and 8 times higher than those of the richest households[21]. In Eastern Cape and Northern Province in South Africa, stunting rates are very high because of poverty levels. African children are more than 5 times stunted and underweight than children of the white population, partly due to persisting inequality [10]. According to a study carried out in Limpopo Province, South African malnutrition rates were found to be high among people with low socioeconomic status especially the rural, black African children [22].

Association between maternal nutrition and growth

Inadequate maternal intake or absorption of food results in poor foetal growth[23]. Maternal undernutrition includes chronic energy and micronutrient deficiencies; this is evident in most countries in sub-Saharan Africa, South-central and South eastern Asia and Yemen where more than 20% of women have a body mass index of less than 18.5kg/m^2. Maternal short stature and low body-mass index have independent adverse effects on pregnancy outcome with the latter being associated with intrauterine growth restriction [5]. Malnutrition has proved to contribute to decrease in brain cellularity of an infant especially if the mother was malnourished during pregnancy[6].

Association between growth and breastfeeding and infant nutrition (post weaning)

Breastfeeding provides healthy growth and development in infants, it not only offers optimal nutrition for babies but also benefits mothers, households, communities and nations[24]. It is recommended that infants should be exclusively breastfed for the first 6 months of life to achieve optimal growth, development and health and to meet their evolving nutritional requirements[25]. Infants should also be provided with nutritionally adequate and safe complimentary foods as breastfeeding continues for up to 2 years of age or beyond[26]. Breast milk is good for the infants because their tissues and organs are still immature and involving them in complex nutrient metabolism limits the ability of the infant to respond to excesses or deficiencies in nutrients intakes[27]. Infants who were exclusively breastfed are said to be at risk of having iron deficiency especially if the mother had iron deficiency, having the prevalence of anaemia among pregnant women is between 25-50% in different parts of South Africa[24].

Various studies have shown negative association between breastfeeding and body mass index (BMI) in childhood and adulthood compared with children who were bottle fed, that is

breastfeeding may have a protective effect against overweight in adulthood, breastfeeding also promotes a healthy life for the infant and increases life expectancy by reducing the risks of infections and allergies[16, 24-27].

Various studies have shown that children who are breastfed for a long period of time in developing countries tend to have anthropometric deficit compared to those who are fully weaned[27]. In South Africa breastfeeding is practiced but not exclusively as recommended by the World Health Organisation (WHO), exclusive breastfeeding is not generally practiced because supplementary feeding is introduced at a very early age [16]. A survey carried on in 1998 by the South Africa Vitamin A Consultative Group (SAVACG) showed that 12% of the infants were never breastfed. According to the South Africa Department of Health (SADHS) only 7% under 6 months were exclusively breastfed and 17% were never breastfed. This agrees with other studies done in South Africa that mothers tend to introduce complimentary foods early[24]. In South Africa the main complimentary type of food introduced to the infant is maize meal which is low in nutrients, high fibre density hence impacting on the infant's nutritional status[17].

International recommendations on infant feeding

Table **1** is a representation of the comparison of infant feeding indicators as recommended by three different International agencies (World Health Organisation, United Nations Children's Fund and World Food Programme). Three key variables were looked at i.e. exclusive breast feeding, breast milk substitutes and complimentary feeding) [28-30].

Exclusive breastfeeding up to from birth up to 6 months of age

As shown in **table 1** the three International agencies emphasis on exclusive breastfeeding up to 6months of age, this is because exclusive breastfeeding optimises infant growth, development and health.

Breast milk substitutes

The three International agencies also share the same views with regards breast milk substitutes, they recommend that breast milk substitutes should only be given to infants with special conditions e.g. if the mother is HIV positive or has active tuberculosis. Use of infant feeding bottles and teats are discouraged because they create a favourable environment for microbial contamination, much emphasis is put on the use of cups instead.

Complimentary feeding

After 6 months of exclusively breast feeding it is recommended that a variety of properly prepared foods rich in energy and micronutrient should be introduced. The mother is recommended to complement breastfeeding with nutrients rich and a variety of foods so as to meet the evolving demands of a growing infant.

Table 1: Shows Infant feeding recommendations by international agencies

INFANT FEEDING	World Health Organisation	United Nations Children's Fund	World Food Programme
Exclusive breast feeding	Recommends 6 months of exclusive breastfeeding	-Exclusive breastfeeding for 6months. -Continue to breastfeed up to 2 years and beyond	-Exclusive breastfeeding for 6 months
Breast milk substitutes	-Emphasis that other breast milk substitutes should be discouraged unless unavoidable. -If used it should provide adequate nutrition for the baby. -Infant feeding bottles and artificial teats are discouraged, cups should be should used instead.	-Recommends that it should only be used under strict condition e.g. Mother is HIV/AIDS positive -Milk powder and prepared milks serves as a growth media for bacteria if not well stored.	-Discourages use of other breast milk substitutes, so as the risks of microbial contamination can be minimized. -Teats and infant feeding bottles are discouraged
Complimentary feeding	- Should be introduced after 6months of exclusive breast feeding. -Nutritional adequate foods should be complemented with breast milk -Food consistency and variety should be increased gradually with increase in age. At 6-8months pureed, mashed and semi-solid foods can be offered. At 8 months nutritious snacks can be introduced, and at 12 months the infant can eat the same meal	-Should start complimentary feeding as from 6months while still breastfeeding up to 2yrs	-Advocates for appropriate introduction to complementary foods after 6 months. -Breast feeding should be complimented with foods.

	eaten by the family. -Vitamin A rich fruits and vegetables should be taken daily. Meat, poultry, fish or eggs should be offered as often as possible. Drinks that have low nutrient value should be avoided. -For adequate growth and development infants of 6-8months requires an energy density of 200kcal/day, 9-11 months needs 300kcal/day and 12-23months needs 550kcal/day		

Association between birthweight, gestational age and growth

Birthweight is an indicator of prenatal exposures and there is evidence to show that there is a strong positive association between birth weight, overweight and obesity risk in later life [31]. Infants who are born with a low birthweight and later on develop a high BMI are at high risk of developing Type II diabetes and hypertension [32]. Studies have shown that it is at age 1-2 years that significant "Catch up" (refers to acceleration in growth after a period of growth retardation) or "Catch down" growth [33, 34], In the Avon Longitudinal study of pregnancy and childhood (ALSPAC) catch up growth between birth and age two was observed to be a risk of central and peripheral childhood obesity and later on contribute to associations between intrauterine growth restriction and risk of diseases in adulthood [33, 35].

Preterm and underweight infants with <2,500 grams are at increased risk for growth abnormalities, developmental delays and chronic illness. Preterm and underweight infants are at nutritional risk because of the difficulties associated with feeding in the neonatal period. Nutrition intervention in the first year of life is the only way that can improve growth and allow better developmental outcomes in low birth weight infants. A weak relationship has been observed between growth of the underweight infants and nutritious dietary intake changes[36].

During pregnancy the maternal nutritional status also affects the infant's body size and composition by production of long-term deficit in foetal lean body mass interfering with the sensitivity of the hypothalamic pituitary adrenal axis which affects appetite and physical growth of the baby[14].

Foetal malnutrition is a predisposing factor to the development of handicaps, including seizures, visual problems, learning disabilities or mental retardations in later years[37]. If malnutrition is severe, breast milk composition and volume will be affected, since the

concentration of some micronutrients (vitamin A, iodine, thiamine, riboflavin, pyridoxine and cobalamin) in breast milk is dependant on maternal health status and intake, hence the risk of infant depletion is increased by maternal deficiency[5].

Association between childhood illness and growth

Infants in developing countries have high rates of infectious and parasitic diseases, this is responsible for higher energy requirements demand. These infectious diseases are important determinants of stunting. Respiratory illnesses contribute to growth faltering but diarrhoea greatly affects child's growth because it is associated with mal-absorption of nutrients hence having a growth limiting effect on the infant [18, 38]. A study has shown that five to sixteen percent of pneumonia, diarrhoea and malaria morbidity are responsible for moderate to severe underweight. Early malnutrition also increases the risk of other chronic diseases later in life such as diabetes, hypertension, renal diseases and cardiovascular diseases which leads to high adult health care costs [39, 40]. This long term outcome is a real concern in the Bt20 cohort since they are experiencing rapid nutrition transition and are relatively affluent compared to developing countries in Sub-Sahara Africa. Therefore, their risk for malnutrition in the long term is lower but their propensity for putting on weight later on in life might be greater and therefore their risk of chronic diseases may also be increased.

1.2.1.2 DIETARY ASSESSMENT METHODS

Dietary intake of individuals can be assessed through various methods such as 24-hour recall, dietary history and food frequency questionnaires which are done retrospectively whereas estimated food records and weighed food records are done prospectively. The type of dietary assessment method to be used greatly depends on the study objectives, characteristics of the study subjects, respondent burden and availability of resources [41, 42].

According to the **Table 2** there is no ideal method for assessing dietary intake because they all have their advantages and disadvantages. 24-h recall, repeated 24-h recall and FFQ are greatly dependant on the respondent memory and hence prone to recall bias and overestimation or underestimation of intakes[43].

The Bt20 cohort used the unquantified FFQ as its tool for dietary assessment because it is an appropriate method for large-scale studies and also an effective method when dealing with groups that are culturally diverse. The FFQ has a low participant burden and it also assesses the habitual feeding practice over the past year [44, 45]. FFQ has also shown validity and reliability in other studies done on dietary assessment methods in a study done to assess elderly diet in Rotterdam and in a study in South Africa to assess the energy and macronutrient intake among 5 year olds [45, 46]. Some of the limitations of using unquantified FFQ are that it's prone to recall bias and the guardians of the subjects tend to over estimate or underestimate the dietary intake because they can't recall the actual frequency of intake [47, 48]. This particular questionnaire was seen used successfully for many years of dietary assessment among South African children [13, 49].

1.2.1.3 DIET DIVERSITY AND FOOD VARIETY SCORE

Essential body nutrients are less likely to be found in one food item (expect breast milk for the first 6 months of life) but rather from a diet comprising of more food items. The more

diverse a diet is the healthier it is said to be, varied diets have been observed to protect the body against chronic diseases, improve longevity and improve health status [50, 51].

Diet diversity score (DDS) is defined as the number of food groups consumed by each child per week and food variety score (FVS) is defined as the number of different food items eaten during the week. Diet diversity and food variety scores are used in predicting nutrition adequacy and can also be used as indicators in monitoring projects [41, 50].

Table 2: Dietary intake assessment methods

Study method	Dietary assessment method	Description	Advantages	Disadvantages
Retrospective	24-h dietary recall	-Recall the exact food intake during the 24hr period	-Inexpensive -Large coverage -High compliance -Quick method & Less likely to alter eating patterns.	-Depends on the responder's memory (recall bias) - Cannot characterise usual intake as a 'snapshot' of a day's intake
Retrospective	Repeated 24h recall	-24-h recalls are repeated during different seasons of the year. -Assesses usual intake	-Estimates the average food intake of individuals over a long time -large coverage -high compliance	-Not feasible to carry out repeated observations on all respondent -Recall bias -Variation affected by study population, nutrient under study and seasonal diet variation
Retrospective	Dietary history	-Has 3 components 1) Overall eating pattern of subject 2) Cross-check (questionnaire on frequency) 3) Subjects record their food intake at home for 3days	-Describes the habitual intake of food over a long time	-Recording is labour intensive -Requires highly skilled interviewers -High respondent burden -Unsuitable for large surveys -Recall bias
Retrospective	Food frequency Questionnaires (FFQ)	-Assess the frequency of food items/food groups consumed during a specific time period. -Assess habitual food intake in cohort studies	-Imposes fewer burdens on respondent. -Results easy to collect and process. -Determines usual consumption	-Recall bias -Subjects tend to overestimate or underestimate intakes
Prospective	Estimated food records	-Foods in the questionnaire are recorded when eaten but portion sizes are estimated	-Less respondent burden compared to weighed food records -Measures actual intake	-Failure to quantify portion size correctly -Number of days are required to show usual intake
Prospective	Weighed food records	-All foods and beverages consumed by the subject are weighed and recorded	-Accurate -Measures actual intake	-Needs literate and numerate respondents only -Expensive, time consuming

1.2.2 OBJECTIVES OF THE STUDY

1) To describe dietary intake patterns (Diet Diversity Score and Food Variety Score) among age one boys and girls in the BT20 cohort study.

2) To describe growth at age one and two among boys and girls in BT20.

3) To describe the prevalence of malnutrition (Stunting, wasting and underweight) among boys and girls in BT20.

4) To determine the association between dietary patterns at age one and growth at age two.

1.2.3 HYPOTHESIS

We propose that there is no association between post-weaning dietary patterns at age one and growth at age two.

CHAPTER TWO

METHODOLOGY

2.0 INTRODUCTION

This chapter covers background information about the study area, study design, criteria used for sample selection and sample size. Methods and materials used when measuring the exposure, outcomes of interest and potential confounders are also described in details. Data analysis has also been described in detail.

2.1 BACKGROUND INFORMATION ON STUDY AREA

South West Township (Soweto) is located 15km south west of Johannesburg, Gauteng province. Contemporary post-apartheid Soweto is the most populous black urban residential area in South Africa holding approximately 1.1 million people as per the 2002 census, 65% of the Johannesburg population resides in Soweto comprising of 29-34 townships. The township was set aside mainly to house black labourers who were working in the mines and industries in Johannesburg, and those working away from the city centre. Soweto has been ranked among the poorest in Johannesburg but on the contrary individual townships are comprised of a mixture of wealthier and poorer residents. Soweto has poor housing, overcrowding, high unemployment and poor infrastructure[52]. Besides tuberculosis, upper respiratory diseases, sexually transmitted diseases, HIV/AIDS, diabetes, hypertension and malnutrition is also a major problem experienced in Soweto[53]. There are major differences that occurred between Soweto during the apartheid period and post-apartheid period; this is shown in the **table 3.**

Table 3 Comparisons between Soweto during apartheid and post-apartheid period.

1990	2008-Present
Malnutrition was a major problem	Malnutrition is still a problem though less prevalent.
Population of less than 1million	Increased population of over 1.1million
Chronic and infectious diseases were rare e.g. HIV/AIDS	HIV/AIDS has become a major problem
Inadequate access to water and sanitation	Adequate access to water and sanitation

Source: http://www.joburg.org.za/soweto/overview.stm

2.1.1BIRTH-TO-TWENTY STUDY

The Birth-To-Twenty (BT20) study is a continuation of the Birth-To-Ten study which is the largest and longest running birth cohort study in Africa. The Birth-To-Ten study was started in 1990 which enrolled participants at birth and consistently during the apartheid period (1990-1992) and continued to the year 2000; it followed up the participants in their first decade of life. It aimed at investigating the biological, environmental, social, economic and psychosocial factors associated with the health of South Africans children from all communities living in Johannesburg/Soweto in Gauteng province [46, 54]. The BT10 was extended to BT20 and the scope of work was extended to look at the risks associated with lifestyle, including sexual and reproductive health, cardiovascular diseases and diabetes[55].

There were 3273 participants that met the cohort inclusion criteria which was restricted to mothers who were permanent residents of the metropolitan areas of Soweto and Johannesburg[2]. There was an under-representation of the whites in the study and this was as

a result of selection bias since the enrolment was being done in public hospitals yet the whites mainly took their children to private hospitals[56] this was however expected since Soweto is predominated by blacks. Anthropometric, socioeconomic status, health, nutrition and demographic data were collected at birth and at 3, 6, 12, 24, 48, and 60 months [2, 54].

2.1.2 STUDY DESIGN

BT20 is a prospective longitudinal study and data was collected from 1990 and presently the age 19 years data collection wave is underway. The current study employs analytical cross-sectional study design.

2.1.3 SAMPLE SIZE

In the Birth-To-Twenty cohort study 3,273 participants had full demographic data (gender, ethnicity, parity, gravidity). The 3,273 participants were subjected to the following exclusion and inclusion criteria.

Exclusion criteria

- Those without dietary data at year one
- Those without growth data at year one and year two.

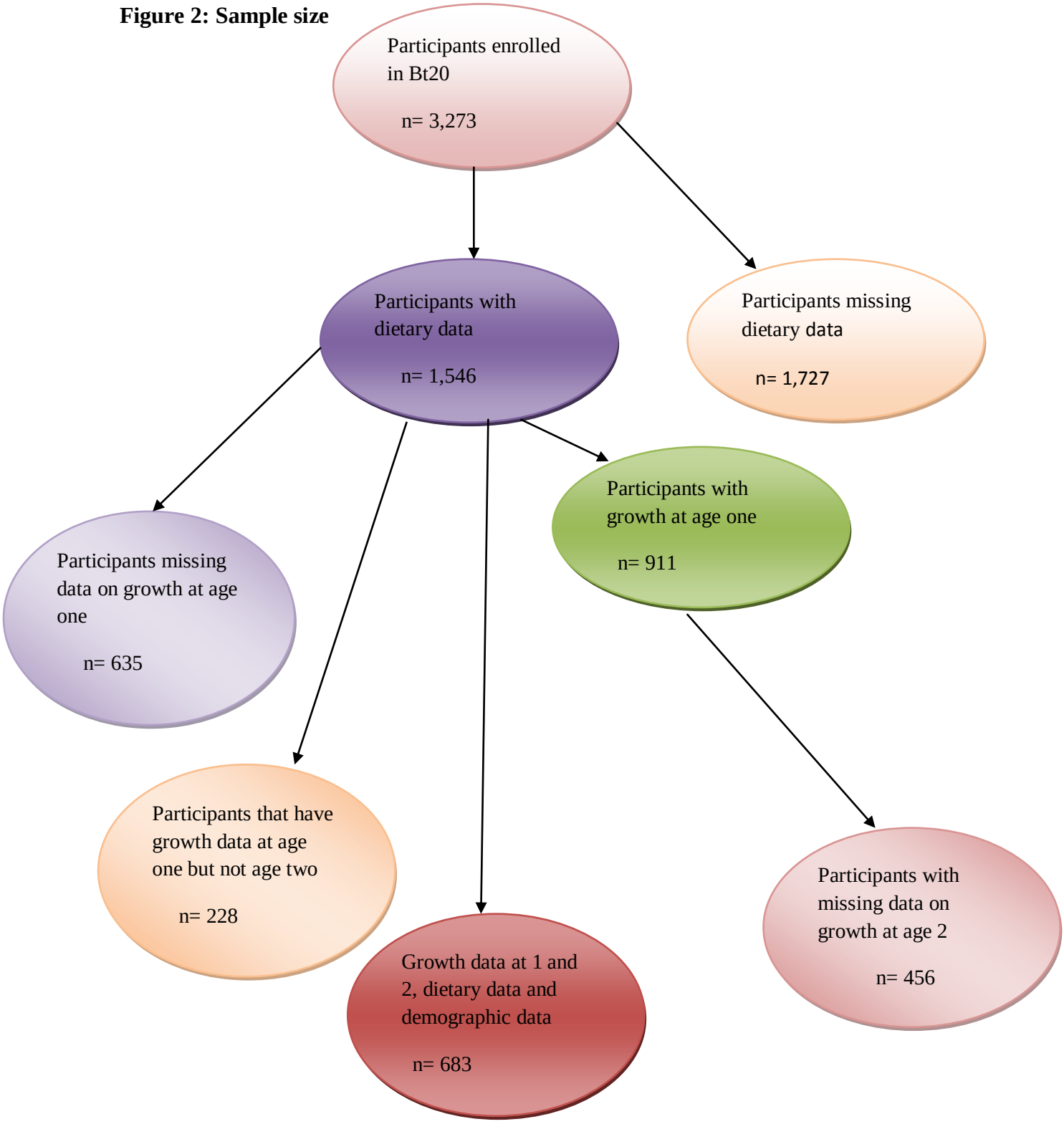
Inclusion criteria

- Those with full demographic data
- Dietary data at year one
- Growth data at year one and year two.

Among the 3,273 participants 1,546 had dietary data and 1,727 did not have. Out of the 1,546 a total of 683 participants had all data (demographic data, growth data at year one and year two, dietary data at year one and full data on general child health at year one). This is

illustrated in **Figure 2** which shows how the final study participants sample was derived. **Figure 2** shows the sample size that remained after subjecting the participants to inclusion and exclusion criteria

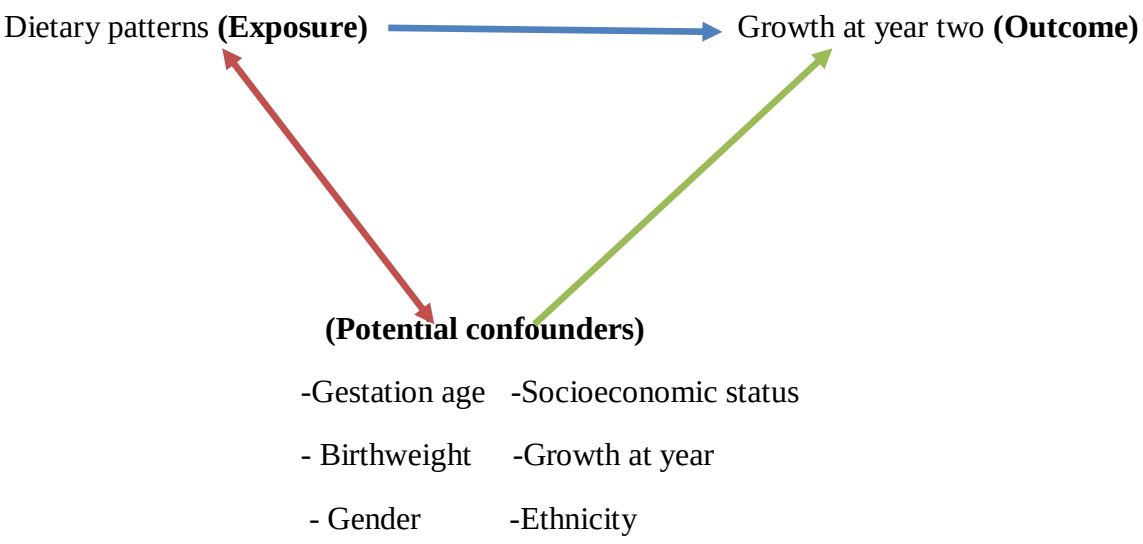
Figure 2: Sample size



2.2 METHODS AND MATERIALS

2.2.1 STUDY VARIABLES

The flow chart below is an epidemiological overview of the study variables. *Exposure* is a factor that is suspected to be associated with the outcome of interest, it can be a harmful substance or a specific behaviour or personal characteristics, and in this case it relates to dietary patterns. *Outcome* is a condition that occurs as a result of exposure and confounder. *Confounder* is a variable that is associated with the exposure of interest and a risk factor for the outcome of interest.



Exposure variable (Dietary data)

In the Bt20 study, caregivers of the one year old infants were interviewed by trained interviewers, by use of Food Frequency Questionnaire (FFQ) which was administered retrospectively to assess the frequency of infant consumption of food items.

The questionnaire had 149 food items of which the caregivers were requested to indicate the child's usual consumption from the given categories; never/seldom, once/month, 2-3/month, 1/week, 2-4/week, 5-6/week, once/day, and 2 or more/day and they were scored 0-7 respectively. The questionnaire did not include specific questions such as the quantity of servings. For each food item the parent/caregiver was asked to estimate the frequency of consumption. Refer **Appendix 5.**

The BT20 used an unquantified FFQ to assess dietary patterns. In 1998 MacKeown performed a validation study in the BTT nutrition assessment method and found it as an appropriate method since BTT study has been carried out in a culturally diverse population (46). A number of validation studies on dietary assessment methods have been done but none of them can be said to be the 'gold standard' method [43, 45, 48, 50].

Frequency of food items consumption

Frequencies and percentages were calculated for:

1. The total number of times each food item was recorded per week was as follows;

   Y= 1/week+2-4/week+5-6/week+7/week+14 or more/week

   Where Y= Total food of each individual food item consumed

2. Number of recordings for each individual food item

$$\frac{X}{Y} \times 100$$

Where X= Total number of items each individual food item was recorded

Y= Total number of recordings for all food items recorded (15,138).

3. Percentage of children consuming the food items

$$\frac{X}{Y} \times 100$$

Where X= Total number of items each individual food item was recorded

Y= Total number of children.

Calculating the FVS and DDS

Counts of consumed food items were used to derive a food variety score (FVS) and a dietary diversity scores (DDS) as described below in detail[41].

Food variety score

Food variety score is the number of different food items consumed over a period of one week, from a possible total of 149 food items (as represented in the FFQ) which reflects the food varieties consumed by the infants. With the use of STATA version 10 mean, minimum and maximum values were calculated for boys and girls separately.

Diet Diversity Score

Diet diversity score is the number of food groups consumed over a period of one week. The food items were classified into 11 categories as shown in the **Table 4** is a modification of food groups recommended by FAO [41, 49, 50]. DDS was calculated from the food items in the UFFQ which were then grouped into food groups and calculation of the mean was done.

Table 4: List for the food groups consumed as presented in the FFQ.

Food groups	Type of food
Dairy and dairy products	-Full cream milk, low fat, skimmed milk, cream, plain and flavoured yoghurt, cheese cheddar, gouda, cottage, custards,
Grains/Cereals and cereal products/Other starch products	-Sweetened cereal, rice krispies, cornflakes, all bran, weetabix, pronutro, oats, maltabella and Mieliemeal-soft, rice, pasta, samp, Mieliemeal-stiff, pizza, bread, biscuits
Meat/Fish	-Fish paste, fish, beef, bolognaise, mutton, pork chops, chicken, pilchards and sardines
Legumes/nuts and legume products	-Baked beans, dried vegetable beans, lentils, peanuts
Vitamin A rich vegetables	-green/yellow/red vegetables, tomatoes
Other vegetables	- white vegetables, potatoes
Fats and oils	-Margarine, butter, peanut butter, oil, salad dressings, ice cream
Fruits	- Apple, banana, orange, mixed fruits, raisins, tinned fruits
Sugars	- Squash/cordial, jam, sweets, chocolates, toffee, jelly, sugar, popcorn, jam
Eggs	-eggs
Miscellaneous	-biscuits, sauce, soup, coffee, tea, gravy

Outcome variables (Anthropometric measurements)

Child's growth at age 1 and growth at year 2 are the outcome variables. Anthropometric data on the height-for-age, weight-for-age and weight-for-height of infants was collected at one year and at two years[(2)]. Length at year one was measured by the use of Harpenden tape measured to the nearest 0.1cm and weight was measured to the nearest complete 0.1kg by the use of a digital weighing instrument (Dismed, USA) [(57)].

Z-scores for the anthropometric variables were calculated according to the WHO 2006 reference, height-for-age Z-score (HAZ which indicates stunting), weight-for-age Z-score (WAZ which indicators underweight), weight-for-height Z-score (WHZ which indicates wasting). A child was considered stunted or wasted or underweight-for-age if their Z-score is

2 standard deviations or more below the 50th percentile for the reference population[58]. Height-for-age, Weight-for-age and Weight-for-height was further categorised into four; normal (Z-Score=0), mild (Z-Score=<-1 to >-2), moderate (Z-Score=-2 to >-3) and severe (Z-Score=<-3)[59].

Potential confounders

Potential confounders were selected based on previously published evidence that they are associated with feeding patterns and growth development [60-62], such as gestation age, illness, birth weight, ethnicity, maternal education, maternal age, socioeconomic status and gender which were obtained at study enrolment and follow-up. At enrolment the following details were assessed with the use of a questionnaire; socioeconomic status, maternal characteristics, gravidity, parity and gestational age.

Table 5: A list of all the potential confounders

(Zero categories "0" is treated as a reference for analysis purposes)

Potential Confounders	Categories with coding
House ownership	0) Owned/rented by another person (reference group) 1) Rental local authority/provided by employer
Type of house	0) House 1) Shack/flat/hostel/shared house/room/garage/cottage
Household assets	0) High 1) Middle 2) Low
Maternal education	0) Post training 1) No formal education/standard 6-8 2) < Standard 3- >8 3) Standard 9-10
Maternal age	0) 20-29 1) 13-19 2) 30-39 3) 40-49
Gestation age	0) 38-42 weeks 1) 36-38 weeks 2) Less than32 to 36
Birthweight	0) 2500-4000grams 1) Less than 2500grams 2) Greater 4000grams
Child illness	1) General infection (Yes (1) or No (0)) 2) Upper Respiratory Infection (Yes (1) or No (0)) 3) Helminthic infections (Yes (1) or No (0)) 4) Gastro-intestinal infection (Yes (1) or No (0))

2.3 DATA MANAGEMENT

2.3.1 DATA EXTRACTION AND CLEANING

STATA version (10.0) was used for data handling, cleaning and statistical analysis. Data cleaning was involving double checking the data entry for missing values, grouping and coding and determining internal consistency.

2.3.2 DATA ENTRY PROCESS

Feeding data which was collected 12 years ago was captured in Microsoft Access 2007 relational database software. Quality control measures were implemented during data entry process such as use of validation keys to avoid capturing of extreme values. Upon completion of data capturing a random selection (with a random number table) of 10% of the captured dietary data (1546) was assessed for errors and accuracy and 1.2% (n=17) of the randomly selected questionnaires were incorrectly captured, this was corrected. The data was cleaned in Ms-Access that is questionnaires that were captured and duplicates were excluded, growth data was also cleaned those who had missing data were coded as "zero" this was corrected to "Missing". Data on breastfeeding, gestational age, socioeconomic status, maternal education and age, ethnicity, birth weight and parity had been previously cleaned and extensively used in several publications. The feeding data was then merged with the other datasets which contained the variables required in the study and with the use of Stat Transfer version 7 it was transferred to STATA version 10.

2.3.3 DATA ANALYSIS

Descriptive analysis

To ascertain whether the selected group (those with dietary data) was a true representation of the greater population which they represent t-test and chi-square tests were done for continuous variables to check if the cohort mean was different from the selected group.

Exposure variable (dietary patterns) frequencies of all food items were calculated and the most frequently consumed food items were described. FVS and DDS were calculated and the means for boys and girls were calculated and compared.

At descriptive level outcome variable (height-for-age, weight-for-age and weight-for-height) which are continuous variable were described by determining their frequencies and proportions. Graphs were constructed to compare boy's growth from girl's growth at year one and two.

Inferential analysis

Outcome variables (HAZ, WAZ, WHZ) are continuous therefore multiple regression analysis was used to assess the association between outcome variable (growth at age 2) and dietary patterns at age 1 and growth at age 2 and control for confounders. Birthweight, HAZ, WAZ and WHZ at age 2 z-scores were calculated according to the latest WHO growth reference[58].

Scores from the dietary data and growth variables were tested for the association. Since the outcome variables were categorical (binary) ordinal logistic regression was used. The P-values were calculated to test for statistical significance at 5% significance level. We also computed the 95% confidence intervals for the estimated parameters. Regression models were fitted and we included all confounders (gestational age, socioeconomic status, breastfeeding, and ethnicity). Linearity was tested by comparing fitted and predicted residuals for the independent variables.

2.3.4 ETHICAL CLEARANCE

The original study being carried out in the Birth-To-Twenty study obtained ethical clearance from the Research Ethics Committee in South Africa. The methods used in this study were in accordance with ethics standards given by the Ethics Committee of the University of

Witwatersrand which governs studies done on human participants. The committee approved and gave the current study a clearance certificate with a protocol number M080979 (**refer appendix 6**). Data for this study will only be used for the purpose of this study. To ensure confidentiality and anonymity of the participants' code names will be used during data processing and reporting.

2.3.5 DISSEMINATION AND UTILIZATION OF STUDY FINDINGS

Upon completion of this study the findings of this study will be disseminated at scientific conferences and published in a peer-reviewed journal.

CHAPTER 3

RESULTS

3.0 INTRODUCTION

The general descriptive analysis of all the study variables, growth at year one and two (stunting, wasting and underweight), and food items that where frequently consumed are described in this chapter. This chapter also looks at catch up/down growth, the association between dietary patterns one and growth at year two, and the potential confounders in the Univariate analysis. It then looks at the factors that were associated with growth at year two in the multivariate analysis.

3.1 GENERAL DESCRIPTION OF STUDY PARTICIPANTS

A total of 3,273 participants were enrolled in the study. Dietary information was available for 1,546 (47.2%) boys and girls for the current analysis while 1,727 (52.8%) did not have dietary data.

A comparison between those with and without dietary data was performed by looking at demographic data and childhood characteristics between those with and those without dietary data: this enhanced the understanding of whether the selected group (those with dietary data) was a true representation of the greater study population. Ethnicity (P<0.001) those with dietary data were more compared to those without, marital status (P<0.001) those without dietary data were more i.e. there were more married mothers compared to those with, for maternal education (p-value= 0.032) those with dietary data were more i.e. there were more mothers with no formal to standard 8 education compared to those without, for house ownership (P-value=0.001) those with dietary data were more compared to those without and for household assets (p-value=0.001) those with dietary data were more i.e. there more

participants in the middle and high socioeconomic group compared to those without. There was no significant differences detected for parity, gestational age, birthweight, maternal age, house type ownership and illness which had they P-value =>0.05 as shown in **Appendix 3**.

A comparison between those with complete data and those with missing data on the growth at age two was done; there was a significant difference with regard to ethnicity (P-value=0.001) and house type ownership (P value=0.001), those with complete data were more compared to those without growth data (refer to **appendix 4**)

General description for the 1,546 participants with dietary data

There was a significant difference in birthweight category among the boys and girls (P-value=0.036), more girls than boys had a low birthweight (less than 2500 grams) 11.7% (92) and boys 8.8% (67), on the other hand more boys than girls had a high birthweight (greater than 4000 grams) 2.8% (21) and girls 1.3% (10). An equal proportion 88% (668) of girls and boys were born with a normal birthweight (2500-4000 grams).

A proportion of 59.6% (452) of the boys were born to mothers who were either single/divorced or widowed and 40.1% (307) were born to mothers who were married whereas 64.4% (507) of the girls were born to mothers who were single/divorced/widowed and 35.6% (280) born to mothers who were married. There was a slight difference in marital status between parents with of boys and girls (P-value=0.049).

There was a statistical difference in household assets by gender with a P-value=0.038, where less girls 24.4% (161) than boys 29.5% (185) were born to families with few household assets (low household assets group), more girls 47.9% (316) than boys 41.2% (259) fitted into the middle group of asset ownership. More boys 29.3% (184) than girls 27.7% (183) were born in households which had high household assets.

No gender differences were found for maternal age, gestation age, parity, maternal education, ethnicity, parity, house type and house ownership, refer to the **Table 6**.

Table 6: Descriptive analysis by gender for 759 boys and 787 girls of the Birth-to-Twenty study, Soweto, South Africa among those with dietary data

Variables	N	Boys		N	Girls		P-value
Demographic							
Ethnicity	759			787			
White		27	3.56%		29	3.68%	
Black		642	84.58%		669	85.01%	0.34
Mixed ancestral origin		66	8.7%		75	9.53%	
Asian		24	3.16%		14	1.78%	
Marital status	759			787			
0=Single/divorced/widow		452	59.6%		507	64.4%	**0.049**
1=Married		307	40.5%		280	35.6%	
Parity	759			787			
1		278	36.6%		310	39.4%	0.26
≥2		481	63.4%		477	60.6%	
Socioeconomic factors							
Maternal age (years)	759			787			
14 – 20		104	13.7%		138	17.5%	
20 – 29		458	60.3%		438	55.7%	0.16
30 – 39		184	24.2%		197	25.0%	
40 – 50		13	1.7%		14	1.8%	
Maternal education	759			787			
0 = No formal education		118	15.6%		107	13.6%	
1 = <std 3 - >std 8		533	70.2%		592	75.2%	0.16
2 = Std 9 – 10		103	13.6%		84	10.7%	
3 = Post training		5	0.6%		4	0.5%	
House type	753			783			
0=Shack/flat/hostel/shared house/garage.		173	22.8%		208	26.4%	0.21
1= House/cottage		580	76.4%		575	73.1%	
House ownership	752			783			
0 = Rented local authority/provided by employer		357	47.0%		398	50.6%	0.26
1 = owned/rented privately		395	52.0%		385	48.9%	
Missing		7	0.9%		4	0.5%	
Assets category	628			660			
Low		185	29.5%		161	24.4%	
Middle		259	41.2%		316	47.9%	**0.038**
High		184	29.3%		183	27.7%	
Childhood characteristics							
Gestational age(weeks)	759			787			
38 – 42 (normal)		571	75.2%		582	73.9%	
36 – 38(mild preterm)		127	18.9%		149	18.9%	0.61
26 - 32(moderate preterm)		33	4.1%		33	4.2%	
Missing		28	3.7%		23	2.9%	
Birthweight (grams)	759			787			
<2500		67	8.8%		92	11.7%	

2500 - 4000		668	88.0%		684	86.9%	**0.036**
4001 - 4800		21	2.8%		10	1.3%	
Missing		3	0.4%		1	0.1%	
Illness							
General infections	716			745			
Not infected		528	73.7%		553	74.2%	0.83
Infected		188	26.3%		192	25.8%	
Respiratory infections	729			763			
Not infected		684	93.8%		708	92.8%	0.42
Infected		45	6.2%		55	7.2%	
Helminthic infections	704			730			
Not infected		699	99.9%		729	99.9%	0.09
Infected		5	0.7%		1	0.1%	
Gastro-intestinal infection	724			750			
Not infected		627	86.6%		666	88.8%	0.19
Infected		5	13.4%		84	11.2%	

3.1.2 DIETARY ASSESSMENT OF FOOD ITEMS FREQUENCY AMONG INFANTS

Overall there were 149 different food items on the FFQ. To get the overall total of recordings (15,138) the number of each food item consumed per week was summed and percentages of all the food items were calculated. Of the 149 food items, 37 of them contributed between 1.0 to 2.58% of the recordings of the mostly consumed foods as shown in the **table 7**. **Appendix 1** is a representation of ranking of all the food items consumed at year one in descending order according to the total number of times each food item was recorded.

Eggs, gravy, bananas, mieliemeal-stiff and mieliemeal-soft 4.55%(total percentage for mieliemeal soft and stiff), plain biscuits, orange, rice, peanut butter, brown bread, average green vegetables, mashed potatoes, flavoured yoghurt and apples contributed each between 2.05-2.58% of all the food recordings. On the other hand minced beef, average yellow vegetables, full cream milk, fruit juice, oil, homemade soup, squash, chicken stew, average fruit, other milk types (Klim, Nespray), cooked tomatoes, cheese cheddar, tea, jelly, ice-cream, pork boerewors, fried fish, beef steak, oats, sweets, Vienna and raw tomatoes contributed to between 1.03-1.89%.

Table 7: Ranking of the 37 most frequently consumed food items per week as presented in the FFQ.

Number	Food items	Number of recordings	%
1	Eggs	391	2.58
2	Gravy	371	2.45
3	Banana	356	2.35
4	Mielmeal-stiff (pap)	351	2.32
5	Plain biscuit	349	2.31
6	Orange	341	2.25
7	Mieliemeal soft (porridge)	338	2.23
8	Rice	336	2.22
9	Peanut butter	331	2.19
10	Brown bread	329	2.17
11	Average green	324	2.14
12	Mashed potatoes	324	2.14
13	Flavoured yoghurt	317	2.09
14	Apple	311	2.05
15	Minced beef	286	1.89
16	Margarine	2.83	1.87
17	Average yellow	272	1.80
18	Full cream milk	271	1.79
19	Fruit juice	270	1.78
20	Oil	255	1.68
21	Homemade soup	252	1.66
22	Squash	246	1.63
23	Chicken stew	240	1.50
24	Average fruit	233	1.54
25	Other milk types	233	1.54
26	Cooked tomatoes	228	1.51
27	Cheese cheddar	226	1.49
28	Tea	224	1.48
29	Jelly	196	1.29
30	Ice-cream	193	1.27
31	Pork boerewors	185	1.22
32	Fried fish	173	1.14
33	Beef steak	173	1.14
34	Oats	165	1.09
35	Sweet sucking (confectionary)	159	1.05
36	Vienna	159	1.05
37	Raw tomatoes	156	1.03

Food Variety Score (FVS)

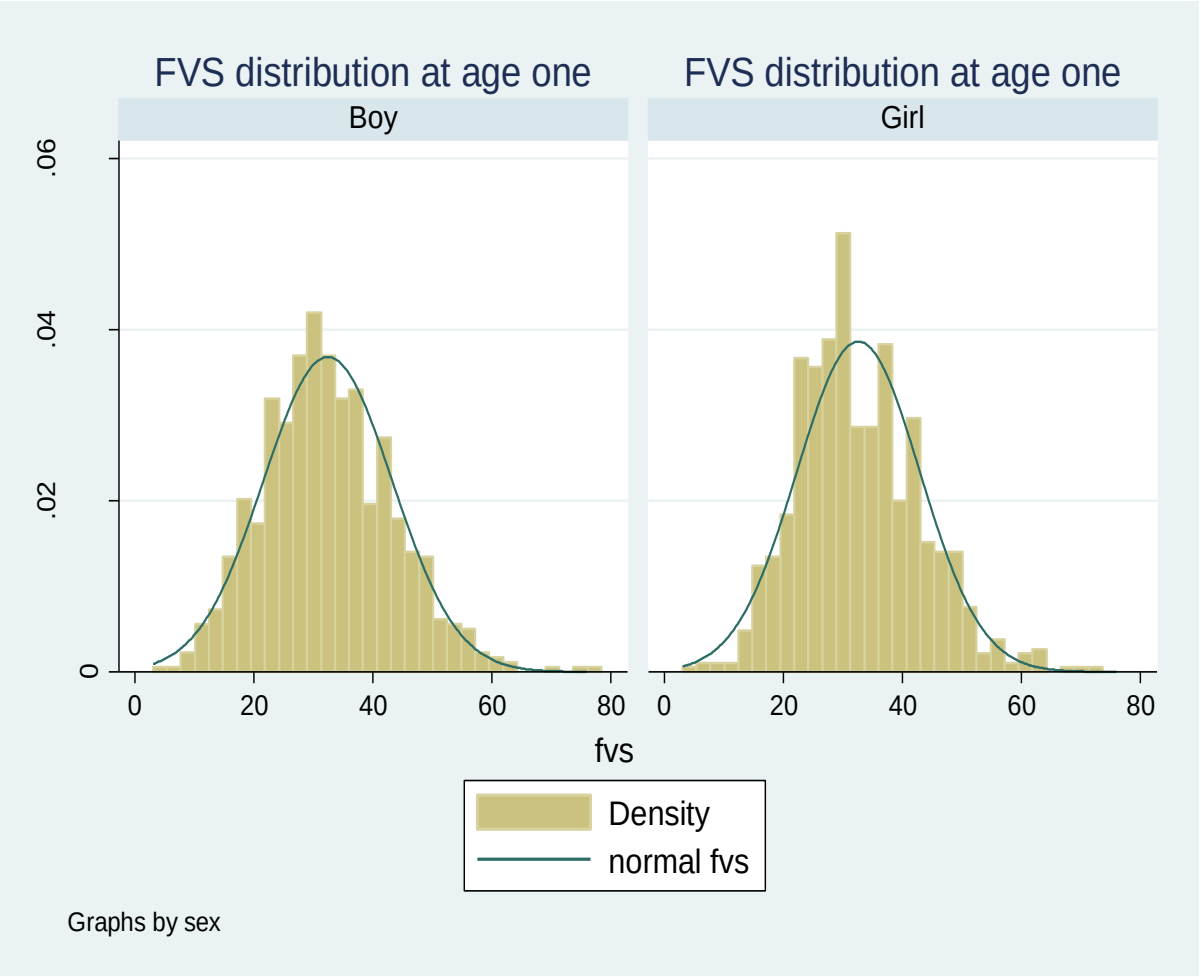
The FVS for boys and girls was not significantly different. **Table 8** (1×1) below shows a summary of the distribution of FVS among boys and girls.

Table 8: Describes the Food Variety Score at year one

Gender	Mean	Minimum	Maximum	Standard deviation
Boys	32.4	5	76	10.8
Girls	32.6	3	73	10.3

Graph 1 shows the distribution of food items (FVS) among boys and girls, from the graph are more likely normally distributed.

Graph 1 Food Variety Scores (FVS) distribution for boys and girls



Diet Diversity Score (DDS)

Table 9 (1×1) below shows that among the boys and girls on average nearly 10 different food groups were consumed on a weekly basis out of the 11 food groups.

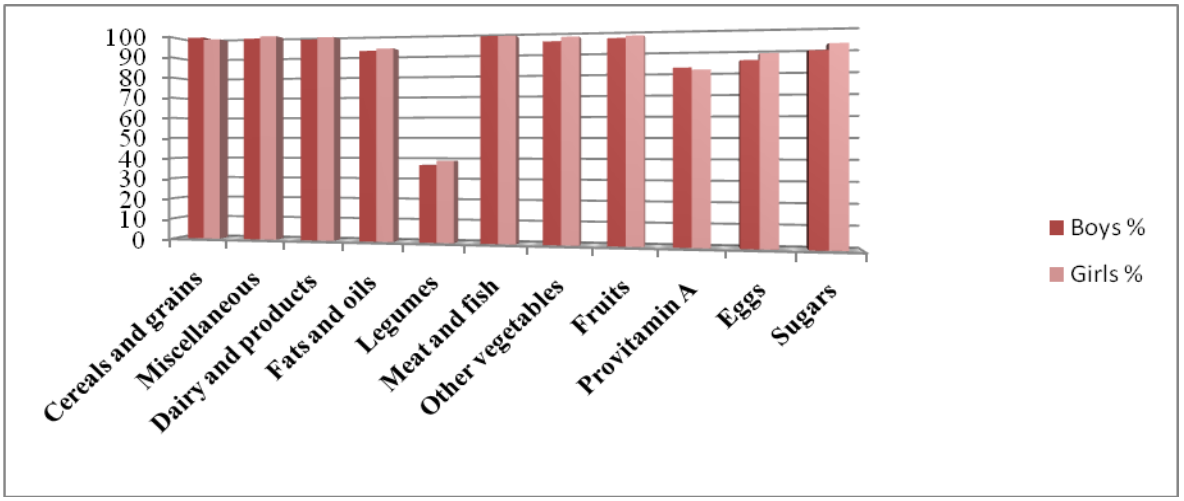
Table 9: Describes the Dietary Diversity Score at year one

Gender	Mean	Minimum	Maximum	Standard deviation	Median
Boys	9.71	3	11	1.2	10
Girls	9.84	3	11	1.1	10

Out of the 11 food groups consumed by the infants a high proportion (90-100%) consumed was cereals/starch/products, miscellaneous (biscuits, coffee, squash, popcorn, tea), dairy and its products, fats and oils, meat and fish and fruits and other vegetables. Pro-vitamin A food group and eggs were consumed by 81-88% of the infants, legumes, nuts and their products were less consumed, which was consumed by 37-39% of the infants.

Graph 2 shows a comparison on the average consumption of food groups (DDS) among boys and girls

Graph 2: Comparing average in-take of food groups (DDS) consumed per week among the infants (boys and girls)

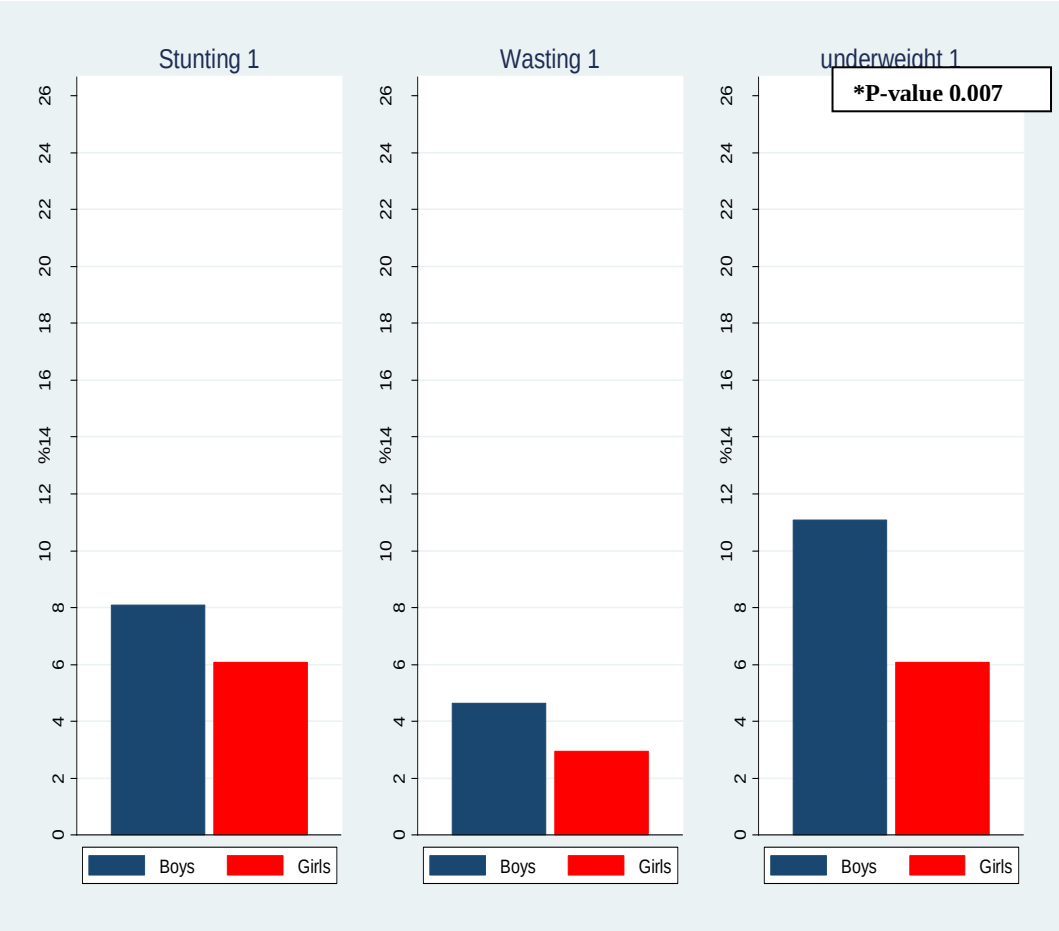


3.1.1 GROWTH CHARACTERISTICS AT AGE ONE AND AT AGE TWO

Year one

Graph 3 shows that there was significant difference in underweight at year one by gender (P=0.007), more boys 11.1% than girls 6.1% were underweight, on the other hand more girls 93.9% than boys 88.9% had normal weight for age.

Graph 3: Comparison of anthropometric measurements (stunting, wasting, and underweight) between boys and girls at year one.

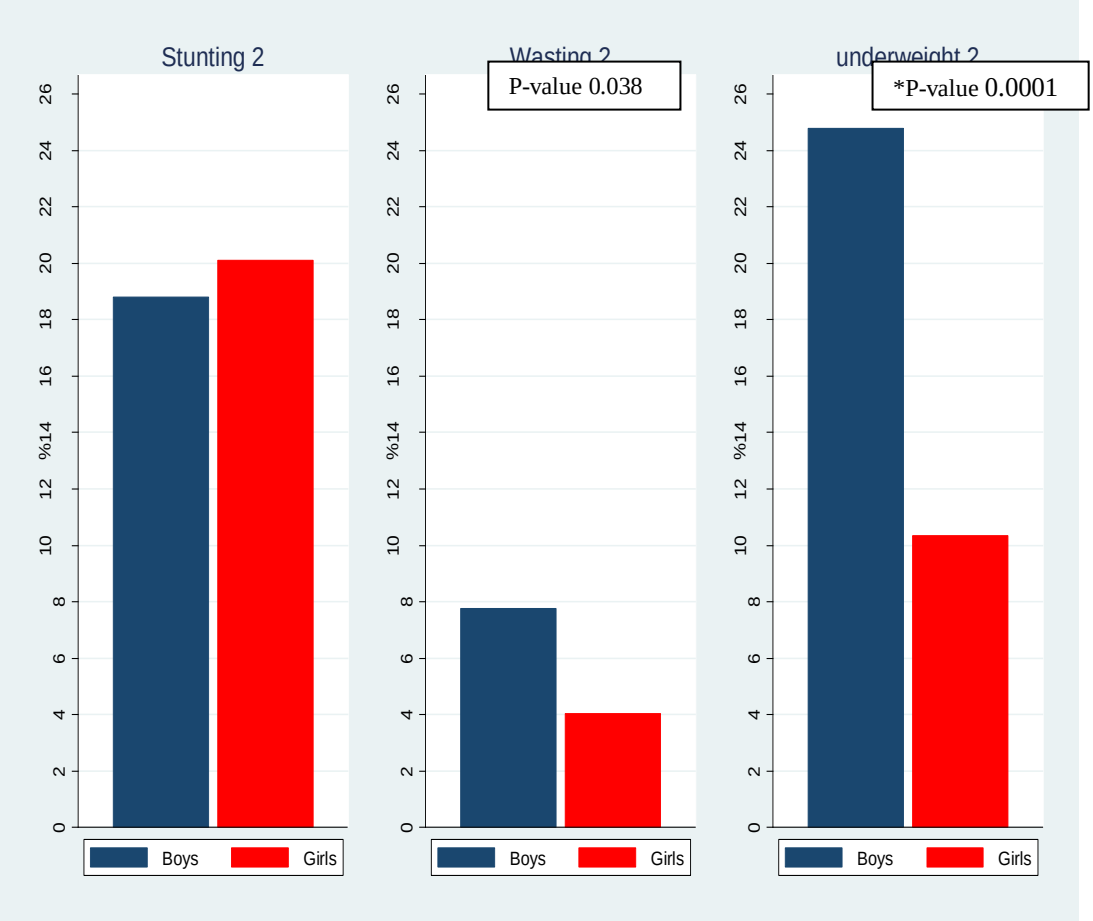


Year two

Graph 4 shows that there was significant difference in underweight at year two by gender (P=0.001), more boys 24.8% than girls 10.3% were underweight.

There was also a significant difference in wasting at year two by gender (P=0.038), more boys 7.8% than girls 4.0% were observed to have a small weight-for-height.

Graph 4: Comparison of anthropometric measurements (stunting, wasting, and underweight) between boys and girls at year two.

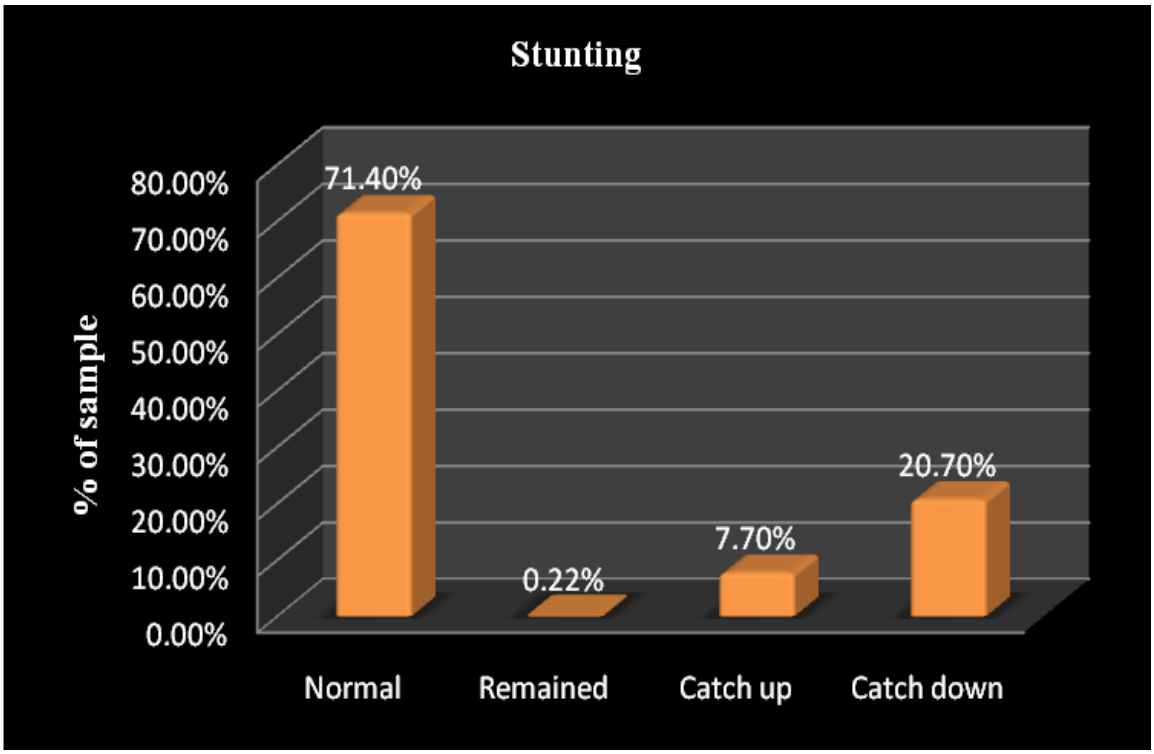


3.1.4 ASSESSING GROWTH CHANGES AT YEAR TWO

Monitoring of height-for-age progress at year two in comparison with growth at year one.

In this section, we present the results on the growth for infants with regards to height-for-age. A proportion of 71.4% (n=325) of infants had normal height-for-age at year two, 0.22% (n=1) of the children who were stunted at year one remained stunted at year two, 7.7% (n=35) of the children who were stunted at year one attained normal height-for-age at year two, whereas 20.7% (n=94) of the children who had normal growth at year one had a small height-for-age at year two as shown in **Graph 5**

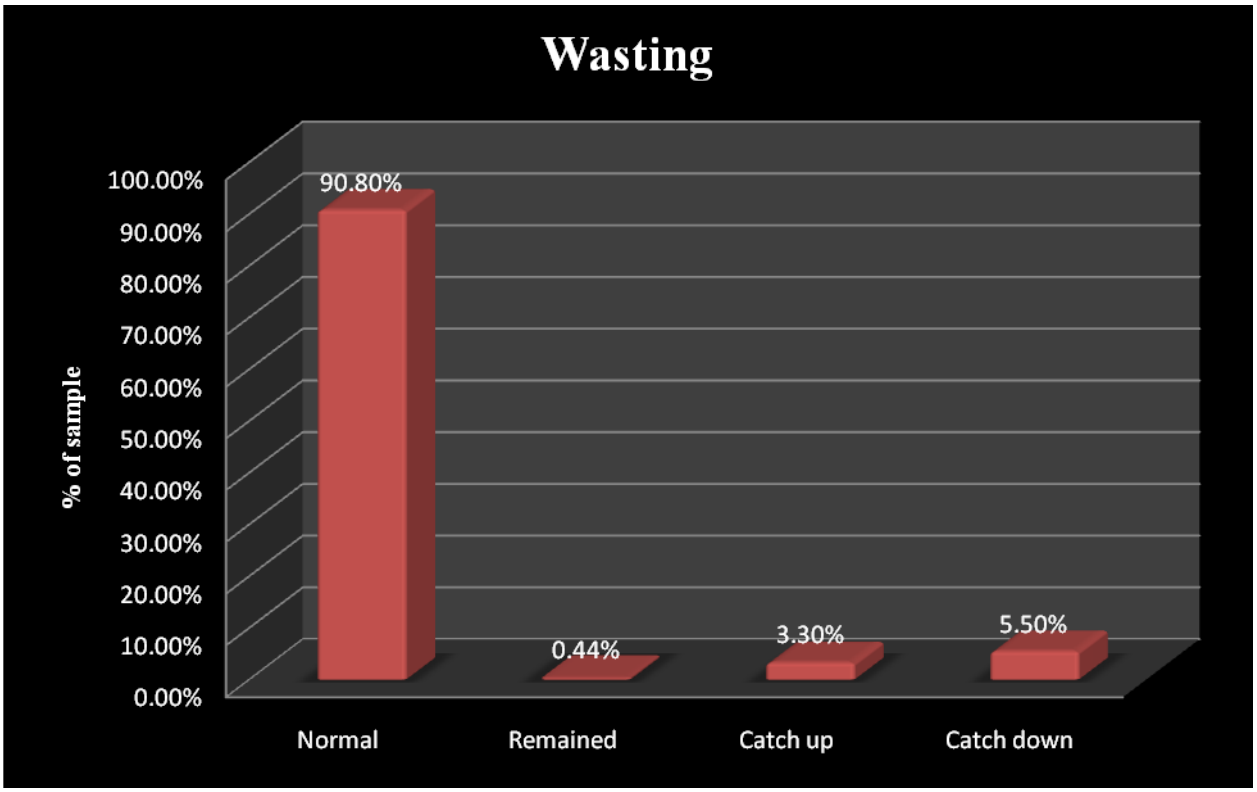
Graph 5: Height-for-age growth progress



Assessing weight-for-height growth progress at year 2 with comparison to growth at year one.

In this section we present growth for infants with regards to weight-for-age. A proportion of 90.8%% (n=413) of infants had normal weight-for-height at year two, 0.44% (n=2) of the children who were wasted at year one remained wasted at year two, 3.3% (n=15) of the children who were wasted at year one attained normal weight-for-height at year two, whereas 5.5% (n=25) of the children who had normal growth at year one had a small weight-for-height at year two as shown in **Graph 6**

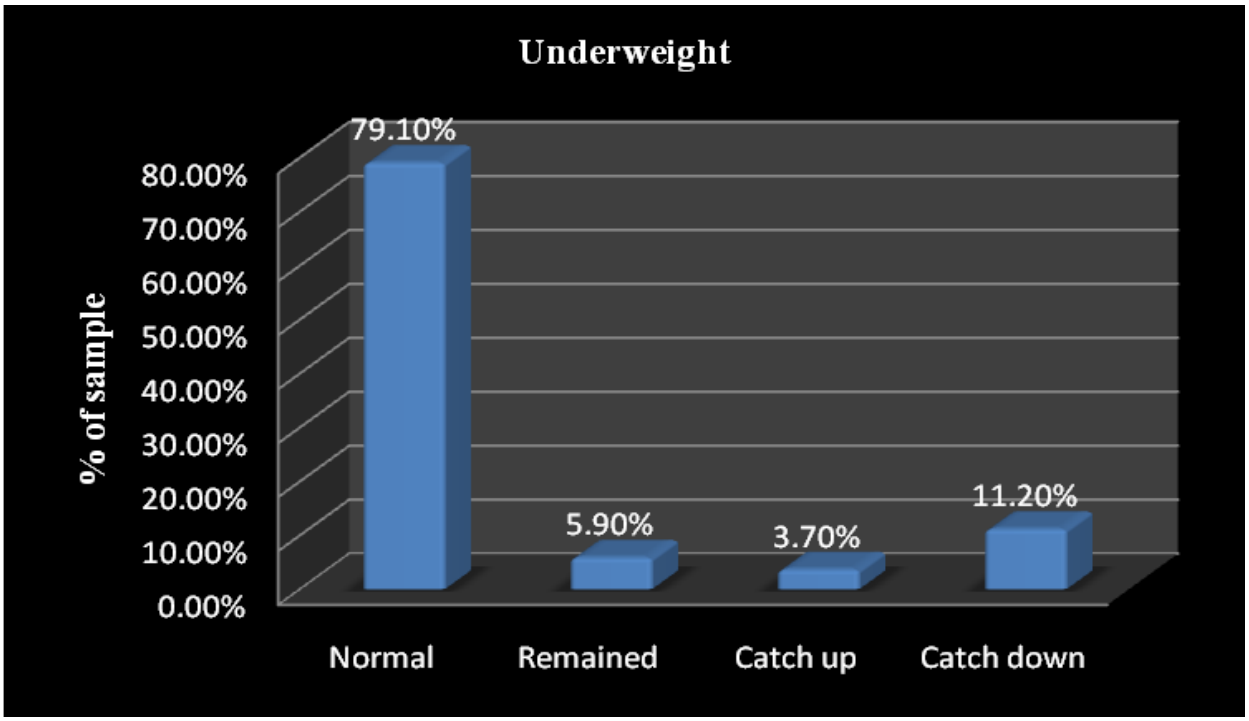
Graph 6: Weight-for-height growth progress



Assessing weight-for-age (underweight) growth progress at year 2 with comparison to growth at year one.

This section presents growth for infants with regards to weight-for-age. A proportion of 79.1% of infants had normal weight-for-age at year two, 5.9% of the children who were underweight at year one remained underweight at year two, 3.7% of the children who were underweight at year one attained normal weight-for-age at year two, whereas 11.2% of the children who had normal growth at year one had a small height-for.age at age two as shown in **Graph 7**

Graph 7: Weight-for-age growth progress at age two



3.1.3 ASSOCIATION BETWEEN DDS AND GROWTH CHARACTERISTICS AT YEAR 2

The mean dietary diversity score did not differ between children who were classified as stunted compared to those who were not, or between children who were classified as underweight compared to those who were not, and between children who were classified as wasted and those who were not as shown in the **Table 10**.

Table 10: Association between mean DDS and growth characteristics at year two

Growth	Number	Mean (95% CI)	P-value
Stunting			
Not stunted	550	9.78 (9.7 – 9.9)	0.15
Stunted	133	9.54 (9.8 – 10.1)	
Wasting			
Not wasted	643	9.8 (9.7 – 9.9)	0.12
Wasted	40	10.1 (9.8 – 10.4)	
Underweight			
Not underweight	564	9.77 (9.7 – 9.9)	0.41
Underweight	119	9.95 (9.7 – 10.1)	

Testing for association between infant feeding practises and growth at age one and two.

All infant feeding variables (breastfeeding, duration of breastfeeding, bottle feeding and introduction to solid foods) were assessed for any association with growth as shown in **Appendix 2**. There was a statistically significant difference in the duration of breastfeeding in that, infants who had a normal height-for-age at age two were breastfed for a longer time (14 months) compared to those who were stunted at year two (Mean=11.8 months, 95% CI 10.2-13.3 P-value 0.02). There was no association between weight-for-age, weight-for-height and infant feeding.

3.2 INFERENTIAL ANALYSIS

3.2.1 UNIVARIATE REGRESSION MODEL

In this section, we present results on association between growth outcomes and various factors (confounders) of child's growth. Refer to **Table 11** which shows the Univariate regression

Stunting at age two

Our data showed that: children born with low birth weight were less likely to have low height-for-age at age two than children born with a normal height-for-age, children born to parents who were staying in rented houses are more likely to be stunted at age two compared to those whose parents stay owned houses. Our data also showed that children born to mothers who single/widowed are more likely to be stunted compared to those who are married. Infants who were stunted at age one are less likely to be stunted at age two than those who were not stunted at age one. Infants who are black ancestral origin and those from a mixed ancestral origin are less likely to be stunted than those from a white origin. On the other hand, food score category, type of house, maternal education, maternal age, gender, parity, gastro-intestinal infection, upper respiratory infection, general infection, duration of breastfeeding and duration of bottle feeding were not significantly (P-value >0.05) associated with stunting at year two in this study.

Wasting at age two

With regard to wasting our data showed that children who were born to a black ancestral origin are less likely to have a low weight-for-height than those born to a white ancestral origin and children with low weight at year one are more likely to have a low weight-for-height compared to those who had a normal weight-for-height at age one, these were the only variables that showed association with wasting at year two

Underweight at age two

With regard to weight-for-age our data showed that: Girls were less likely to be underweight at age two than boys, children who had a low weight-for-height at age one and low weight at age one are more likely to be underweight at age two compared to those who had a normal weight-for-height and children born to a black ancestral origin are more likely to be underweight at age two compared to those who were born to children born to a white ancestral origin, children with low birth weight are more likely to be underweight at age two compared to those who had normal birth weight, these were the variables that were significantly associated with underweight at age two.

Table 11: Univariate analysis

Variables	Stunting			Wasting			Underweight		
	OR	**95%CI**	**P-value**	**OR**	**95%CI**	**P-value**	**OR**	**95%CI**	**P-value**
Ethnicity									
Whites	1			1			1		
Blacks	0.29	(0.158 – 0.55)	0.0001*	0.14	(0.038-0.53)	0.04*	8.65	(1.17-63.56)	0.034*
Asians	0.47	(0.086 – 2.64)	0.39				6.43	(0.34 – 114.97)	0.206
Mixed ancestral origins	0.40	(0.18 – 0.89)	0.025*				25.7	(3.36 – 196.8)	0.002*
Food category									
Very High	1			1			1		
Very low	0.89	(0.49 – 1.6)	0.72	0.41	(0.12-1.58)	0.19	0.74	(0.36-1.5)	0.403
Low	0.64	(0.35 – 1.1)	0.13	1.17	(0.45 – 3.05)	0.75	1.62	(0.89 – 2.9)	0.11
Average	0.87	(0.49 – 1.6)	0.66	1.07	(0.39 – 2.95)	0.89	1.02	(0.53 – 1.9)	0.93
High	0.6	(0.35 – 1.1)	0.12	1.28	(0.50 – 3.29)	0.60	1.1	(0.59 – 2.1)	0.75
Type of house									
Cottage	1			1			1		
Shack/hostel	1.04	(0.64-1.69)	0.86	2.2	(0.78 - 6.39)	0.36	1.51	(1.09-2.07)	0.25
House ownership									
Rented	1			1			1		
Own	1.51	(1.02-2.2)	0.037*	0.77	(0.4-1.46)	0.42	0.75	(0.51-1.12)	0.16
Household assets									
High	1			1			1		
Middle	0.4	(0.26-0.65)	0.001*	1.1	(0.5 – 2.39)	0.817	1.1	(0.67 – 1.78)	0.71
Low	0.7	(0.42-1.33)	0.326	1.2	(0.4 – 3.3)	0.75	1.1	(0.56 – 2.09)	0.80
Maternal education									
Post training/std	1			1			1		
No formal/std 3-8	1.38	(0.72-2.6)	0.334	0.7	(0.29 – 1.76)	0.47	0.73	(0.41-1.29)	0.28
Marital status									
Married	1			1			1		
Single/divorced	2.05	(1.4-3.01)	0.0001*	1.64	(0.87-3.12)	0.12	119	(0.79-1.78)	0.39
Gender									
Boys	1			1			1		
Girls	1.08	(0.74-1.59)	0.66	0.49	(0.25-0.97)	0.04*	0.35	(0.23-0.54)	0.001*
Parity									
1	1			1			1		
2 or more	1.35	(0.89-1.96)	0.16	1.03	(0.54-1.97)	0.92	0.97	(0.65-1.45)	0.91

Gestation age Normal Preterm	 1 0.59 (0.36-0.99) 0.050~	 1 1.21 (0.58-2.53) 0.62	 1 1.37 (0.87-2.17) 0.18
Birthweight Normal Underweight	 1 0.07 (0.032-0.54) 0.005*	 1 1.6 (0.58-4.12) 0.38	 1 2.95 (1.66-5.24) 0.0001*
Gastro-intestinal infection Not infected Infected	 1 0.97 (0.54-1.74) 0.93	 1 1.57 (0.67 – 3.67) 0.30	 1 0.8 (0.43-1.51) 0.49
Upper respiratory infection Not infected Infected	 1 1.37 (0.71-2.6) 0.35	 1 0.29 (0.04 – 2.18) 0.23	 1 0.46 (0.18-1.19) 0.11
General infection Not infected Infected	 1 0.67 (0.42-1.08) 0.106	 1 1.37 (0.67 – 2.8) 0.38	 1 1.4 (0.91-2.2) 0.125
Duration of breastfeeding Over 6months Less than 6 months	 1 0.63 (0.42-0.94) 0.026*	 1 1.02 (0.51-2.08) 0.94	 1 0.75 (0.49-1.15) 0.18
Duration of bottle-feeding Less than 6months Over 6months	 1 1.04 (0.64-1.74) 0.87	 1 0.78 (0.35-1.74) 0.54	 1 1.09 (0.63-1.91) 0.74
Introduction to solid foods After 6months Before 6months	 1 0.6 (0.21 – 1.7) 0.35	 1 1.8 (0.52-6.13) 0.36	 1 0.69(0.23-2.01) 0.49
Stunting at year 1 Normal Stunted	 1 0.09 (0.013 – 0.73) 0.023*	 1 1.5 (0.43 – 5.23) 0.53	 1 5.25 (2.58 – 10.6) 0.53
Wasting at year 1 Normal Wasted	 1 1.49 (0.43 – 5.23) 0.53	 1 2.2 (0.47 – 10.2) 0.31	 1 3.7 (1.47 – 9.32) 0.006*
Underweight at year 1 Normal Underweight	 1 5.25 (2.59 – 10.7) 0.0001*	 1 2.8 (0.99 – 7.73) 0.051~	 1 11.12 (5.71 – 21.9) 0.001*

***if P-value <0.05**

3.2.2 MULTIPLE REGRESSIONS

Multiple regression analysis is an important tool to assess the effect of a response against many variables that are believed to be correlated. In the univariate analysis we investigated the relation between infant growth (stunting, wasting and underweight at age two) and food score category, ethnicity, gender, birth weight, type of house, maternal education, maternal age, gender, parity, gastro-intestinal infection, upper respiratory infection, general infection, duration of breastfeeding and duration of bottle feeding individually. However it well known that type of house and maternal education are related and infant feeding and growth are known to have high correlation. Hence, we expect the effects of infant feeding towards infant growth in presence of infections to vary. So it was of interest to tests the significance of these factors in presences of other correlated variables against growth. So we conducted a multiple regression analysis to investigate the effect of: ethnicity, gender, birth weight, type of house, maternal education, maternal age, gender, parity, gastro-intestinal infection, upper respiratory infection, general infection, duration of breastfeeding and duration of bottle feeding , in presence of other related factors like food score category . We note that ethnicity, house ownership, household assets, marital status, duration of breastfeeding, growth at age one and birth weight are retained in the multiple regression models because they were statistically significant at univariate model **(Table 11)** and expected to alter the effects of infant growth at age two against infant feeding. Ethnicity, gender, infant growth at age one and birth weight we noted to be statistically significant at the multivariate level as shown in **Table 12.**

Stunting: Blacks were less likely (OR=0.44) to be stunted compared to other racial groups (P=0.032 CI 0.21 to 0.93) when birthweight, stunting at year one are kept constant. Infants who were stunted at year one are less likely (OR=0.12) to be stunted at year two compared to those who had normal height-for-age at year one (P=0.038 CI 0.016 to 0.88) after adjusting for birth weight and ethnicity. Babies who were born underweight are less likely (OR=0.1) to

be stunted at year two compared to those who had a normal birthweight (P=0.023 CI 0.013 to 0.73) after adjusting for stunting at year one and ethnicity.

Wasting: There was an interaction between ethnicity and underweight at year one, ethnicity was then stratified and it showed that mixed ancestral origins who were underweight at year one were more likely (OR=5.2) to be wasted at year two compared to blacks who were underweight at year one (P=0.043 CI 1.06 to 25.6) after adjusting for gender.

Underweight: Mixed ancestral origins were 24.5 times more likely to be underweight (P-value=0.003, CI =2.88 - 208.1) compared to whites having adjusted for gender, underweight and wasting at year 1 and birthweight. Girls were less likely to be underweight (OR=0.44) compared to boys (P=0.007, CI 0.25 to 0.79) having adjusted for ethnicity, birth weight, underweight and wasting at year one. Those who were underweight at birth were 3.3 times more likely to be underweight at year 2 (P=0.01, CI 1.11 to 2.29) compared to those with normal birthweight having adjusted for ethnicity, gender, underweight and wasting at year one. The gaps in the table indicate that the variables were not significant.

Table 12: Multiple regression

Variables	Stunting at year 2			Wasting at year 2 (blacks)			Wasting at year 2 (mixed ancestral origins)			Underweight at year 2		
	OR	**95%CI**	**P-value**	**OR**	**95%CI**	**P-value**	**OR**	**95%CI**	**P-value**	**OR**	**95%CI**	**P-value**
Food intake category												
Very high	1			1			1			1		
Very low	0.99 (0.46 – 2.13)		0.98	0.61 (0.05 – 6.95)		0.69	0.65 (0.03 – 14.2)		0.78	0.69 (0.23 – 2.02)		0.49
Low	0.58 (0.27 – 1.24)		0.16	1.82 (0.32 – 10.3)		0.50	1.58 (0.14 – 17.4)		0.71	1.41 (0.57 – 3.45)		0.45
Average	0.72 (0.34 – 1.56)		0.41	2.62 (0.48 – 14.3)		0.26	0.23 (0.01 – 4.6)		0.33	0.59 (0.21 – 1.63)		0.33
High	0.47 (0.22 – 1.01)		0.05	1.39 (0.25 – 7.93)		0.29	2.1 (0.17 – 26.0)		0.57	1.09 (0.44 – 2.68)		0.85
Underweight at year 1												
Normal				1			1			1		
Underweight				2.3 (0.58 – 8.90)		0.24	5.2 (1.06 – 25.6)		0.043**	11.97 (5.10 – 28.13)		0.0001*
Birthweight												
Normal	1									1		
Underweight	0.1 (0.013 – 0.73)		0.023*							3.31 (1.48 – 7.40)		0.004*
Wasting at year 1												
Normal										1		
Wasted										0.52 (0.13 – 2.08)		0.36
Gender												
Boys				1			1			1		
Girls				0.77 (0.27 – 2.16)		0.16	1.7 (0.41 – 7.04)		0.46	0.44 (0.25 – 0.79)		0.007*
Stunting at year one												
Normal	1											
Stunted	0.12 (0.02 – 0.88)		0.038*									
Ethnicity												
White	1									1		
Blacks	0.44 (0.21 – 0.93)		0.03*							6.6 (0.81 – 54.2)		0.078
Asians	0.58 (0.10 – 0.88)		0.55							10.3 (0.5 – 199.5)		0.124
Mixed ancestral origins	0.59 (0.24 – 1.43)		0.24							24.5 (2.9 – 208.1)		0.003*

***shows P-value <0.05**

**** shows interaction**

CHAPTER FOUR

4.0 DISCUSSION

Introduction

In this chapter we will discuss the results from the analysis, starting with the main study findings with regard to infant feeding and growth. Secondly, we will compare the study findings with other findings from previous studies and thirdly we will highlight some of the limitations and strengths of the study.

MAIN FINDINGS

Overall, this study did not observe any association between post-weaning dietary patterns (supplementary foods) and growth at year two, however there was an association between duration of breastfeeding and infant growth at year two, infants who were breastfed for a shorter duration were stunted compared to those who were breastfed for a longer duration. A number of studies have shown that sufficient infant feeding results to positive progress in terms of growth [63-66], on the contrary this current study does not show any association between dietary patterns(supplementary foods) and growth.

SAMPLE SELECTIVITY

Comparison demographic details between those with dietary data (1546) and those without (1,727)

A comparison was done to evaluate sample selection; significant difference was observed for the following variables maternal education, marital status, ethnicity, household assets and house type. This shows that there was selection bias i.e. sample size was not a 100% a representative of the cohort hence the findings can not be generalised.

Comparing demographic details for those with complete data (683) and those with missing growth data at age two (456).

A significant difference was observed with regard to ethnicity and type of house, those with complete data were more compared to those with missing data on growth. This shows that there was selection bias and the selected group was mainly representing whites with regard to ethnicity and those staying in cottages or houses unlike those staying in shacks or hostels.

INFANT DIETARY PATTERNS

Breast feeding and introduction to solid foods

This study observed that infants who were breastfed for a longer duration had normal height-for-age at age two compared to those who were breastfed for a short duration, this is in line with other studies that showed that infants who were breastfed were taller (height-for-age) in infancy and adulthood[67]. However, a similar study done in Peru 1997observed a negative association between prolonged breastfeeding duration and stunting [68], this might be the case because they had a relatively small sample (n=134) compared to the current study.

In this study, 96% of the infants were introduced to solid foods when they were less than 6months, a number of studies have found that in the urban and rural areas of South Africa infants are introduced to supplementary foods at a very early age[69-71]. Early introduction to supplementary foods is not only practiced in South Africa but also developed countries as shown in various research [72-74]. Some studies in developing countries have shown that when solid foods are introduced to an infant too early the possibility of having negative effects on growth were high; introduction to solid foods too late also results to growth faltering since breast feeding alone does not meet the evolving needs of a growing infant [75].

Previous studies have reported similar findings as this study with regards to dietary diversity in that the staple foods in South Africa mieliemeal-soft (in the form of porridge and stiff mieliemeal) is the main supplementary foods given to infants and it ranked the highest, rice too was commonly consumed among the one year olds [16, 49], with it ranking number eight. Meat and fish, Cereals and grains, Dairy and dairy products, vegetables, fruits, oils and fats and eggs were highly ranked in this study (**Refer to Appendix 1**). This current study shows that miscellaneous food items, sugars and fats are frequently consumed, these findings are in line with others studies that have shown a major shift from the consumption of food items low in fat, high in unrefined carbohydrates and fibre to consumption of food items with increased fats, sugars, salt and refined foods [41, 49] [76]. This study also observed low consumption of legumes and its products whose consumption rate was less than 40% among the boys and girls. Low consumption might be due to nutrition transition (more intake of sugars, fats and refined foods), cost of legumes or scarcity of legumes in the urban areas. This study has shown that sugars, miscellaneous and fat food items are mainly consumed by infants yet low in nutrients but has contributed to the high diet diversity score. From this we concluded that calculating DDS and FVS only is not suffice to evaluate infant nutrition, rather the type of nutrients given to an infants diet and the amount.

Semi-quantified food frequency questionnaires (SFFQ) are said to overestimate the nutrient intake as reflected by the difference in means and ratio obtained in food records which is greater than 100%, diet records seemed to have least correlated errors compared to SFFQ[45] . In this is study seems there may have been overestimation of the frequencies since the questionnaire was long and maybe the child's primary caregiver wanted to tick all food items just to show the researcher that they feed their child properly. However this is unproven and is only speculation. Underestimation and overestimation in FFQs seemed to mainly depend

on what the questionnaire comprises i.e. if the actual intake of a nutrient is not adequately covered by the FFQ then underestimation is bound to occur and vice versa[47].

Food Variety Score and Diet Diversity Score

This study observed a high nutritional diversity among the boys and girls refer to **Table 8 and 9** this may be explained by the following; better socioeconomic status since most of the participants belonged to the middle and high socioeconomic group, availability and easy access to food items since this cohort resides in an urban environment. In a National study carried out in 1999, to assess nutritional adequacy among infants showed found a DDS of 3.6 and FVS 5.5 which is quite low compared to other studies done in developing countries the difference might be due to the different dietary assessment methods used (24-hour recall and a food frequency questionnaire) and maybe due to the difference in sample size (n=2894) [12, 41].

INFANT GROWTH

A relatively large number of infants 20.5% (n=164) were underweight at birth, the prevalence of stunting among the boys rose from 8% at year one to 19% at year two, wasting demonstrated a slight increase from 5% to 8%, underweight too showed a sharp increase from 11% to 25%. Among the girls stunting prevalence increased from 6% at year one to 20% at year 2, wasting slightly rose from 3% to 4% and underweight from 6% to 11%. This shows that a greater percentage of boys were malnourished compared to the girls. This could have been as a result of intrauterine growth restriction which might have been due to maternal nutrition, age, maternal weight during pregnancy and parity[77] [78], since in this study dietary patterns was diverse. The sudden increase in the prevalence of malnutrition at age two might be as a result of introducing supplementary foods that are low in nutrients e.g. carbonated drinks and sugars as shown in **Appendix 1**, the association between early

introduction to supplementary foods and infant growth has also been observed by other researchers, they observed that food items like tea and sugars reduces breast milk consumption and hence the increase in malnutrition prevalence [16].

In a study carried out in Limpopo Province 48% of children were stunted, 10% were underweight and few were wasted, this was high compared to this study because of difference in settings in that Limpopo is in the rural areas, difference in socioeconomic status and the Limpopo study looked at children who were three years whereas this study looked at two years old [7].

We are mainly concerned with stunting because it has adverse effects on the child's future health and economic well being, stunting delays mental and intellectual achievement which in turn affects school performance and also impairing adult productivity hence affecting economic productivity [3, 15].

In this study there was a 7.70% catch up growth and 20.7% catch down with regards to height, weight for height 3.30% catch up and 5.5% catch down and 3.7% catch up and 11.2% catch down for underweight. Catch up growth in this current study maybe as a result of exposure to better environments and good nutrition or high food intake (As shown in **table 7**) for those that were small at birth, on the other hand catch down growth maybe as a result of inappropriate feeding practices or gastrointestinal infections. Studies have shown that rapid catch up in infants is associated with risk factors of obesity, hypertension, abnormalities in lipid metabolism, blood coagulation and Type II diabetes especially those born with low birth weight [32, 79]. Catch up growth has been related to infants whose mothers had low birth weight, primiparous pregnancy and who smoked during pregnancy as these are said to be restraining factors for growth[33].

FACTORS ASSOCIATED WITH INFANT GROWTH.

In addition to the non-dietary variables (birthweight, stunting and underweight at age one, gender and ethnicity) this study found to be associated with stunting at age two, other studies in developing countries have found lower maternal age, low maternal weight, and children from families where one or more siblings have died, low birthweight, infections, broken families or death of either parent determine infant growth[75]. In a study done in Yemen to investigate the relationship between feeding practices and growth observed that breast feeding was associated with weight-for-length and weight-for-age, and introduction of other foods in the infants diet was associated with length-for-age[80], our study on the contrary found no association between infant feeding practices (complimentary foods) and their growth, rather found an association between height-for-age and duration of breastfeed.

This study also observed that stunting at year one is not a predictor for being stunted at age two but rather a protective measure this may be because of better socioeconomic status hence improved living standards whereas, in a study carried out in Uganda to determine the predictors for poor growth among infants and children stunting was associated with socio-economic status, environmental, anthropometric, health and morbidity factors[81]. Underweight at age one in this current study was found to be a predictor for wasting and underweight at age 2, this is in line with a study conducted in western Kenya which showed that infants are more likely to be underweight and stunted at age two especially those introduced to solid foods early [82].

There was no association between dietary patterns at year one and growth (height-for-age, weight-for-height and weight-for-age) at year two. This might be because the study employed the use of unquantified FFQ and maybe using a method that measures the quantities of foods eaten would likely show different findings. The non-significant results may also be as a result

of the short period of observation (1-2 year olds), if the study was observed for a longer duration say 5 years different findings are more likely to be observed.

LIMITATIONS OF THE STUDY

Considering the findings of this cohort study it is important to bear in mind the following limitations:

- Firstly, the sample size was not a 100% a representative of the cohort hence the findings can not be generalised. There was no significant differences was detected for parity, gestational age, birthweight, maternal age, house type ownership and illness which had they P-value =>0.05 as shown in **Appendix 3**. Selection bias has been observed in this study i.e. the selected group with regard to ethnicity, maternal education, marital status and type of house ownership is not a 100% representative to the cohort.

- Secondly, the analysis was restricted to variables in the dataset hence analysing additional variables that would have influenced the findings were not possible e.g. maternal nutrition, infant morbidity and quantity of food servings, maternal body composition and maternal-child interaction.

STRENGTHS OF THE STUDY

- In this study, data on growth and demographics was available for all the participants, this made it possible for us to compare those who had dietary information and those who did not have, and identify the differences that existed between the two groups **(Refer to Appendix 3**).

- BT20 is a longitudinal study the participants are followed up, this enhances the quality of the data, this made it possible to look at the relationship between dietary data at age one and growth at age two.

- In the BTT study the characteristics of the family was collected at the very beginning of the study and this has made it possible to relate the current findings with the previously collected information e.g. growth and maternal age, socioeconomic status.

- This study has observed some factors that were not included in the data yet they are vital in child's growth (maternal nutrition, quantities of food servings and maternal-child interaction), with this in mind this study can be used to inform future prospective studies on what should be included in the study.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The aim of this project was to determine whether there was an association between post weaning dietary patterns at age one and growth at age two. The results of this study highlights that dietary patterns at age one has no association with growth (height-for-age, weight-for-age and weight-for-height) at age two. However growth at age one, birthweight and ethnicity remained significant predictors for infant growth, this shows that there is need to improve the underlying and immediate causes for malnutrition refer to **figure 1**.

This study showed that infant dietary diversity, this means that the infants consumed a variety of food items hence diet adequacy. Miscellaneous (tea, coffee) and sugars are highly consumed by the infants this should be addressed and encourage feeding infants with foods rich in nutrients, low in fat and sugar.

There was a significant difference among boys and girls with regard to malnutrition at age one, more boys than girls were underweight at age one. At age two more boys than girls were underweight and wasted.

An increase in malnutrition prevalence was observed from age one to two, the prevalence of stunting among the boys rose from 8% at year one to 19% at year two, wasting demonstrated a slight increase from 5% to 8%, underweight too showed a sharp increase from 11% to 25%. Among the girls stunting prevalence increased from 6% at year one to 20% at year 2, wasting slightly rose from 3% to 4% and underweight from 6% to 11%. This shows that a greater percentage of boys were malnourished compared to the girls.

This study observed a significant difference with regard to weight-for-age at age one, more boys than girls were underweight, at age two more boys were wasted and underweight as compared to girls.

5.2 RECOMMENDATIONS

This study has shown the association between non-dietary factors (birthweight, growth at year one, gender, and ethnicity) and growth at age two. Future research projects should target factors that would contribute to growth faltering at year two other than dietary pattern.

Essential factors (potential confounders) such as maternal conditions during pregnancy, maternal nutrition and quantities of food intake (portions) among the infants should always be measured when trying to evaluate infant growth.

There is need to emphasis on maternal nutrition during pregnancy since this mainly contributes to the child's birthweight which in turn is a predictor for both growth at age one and two. Inappropriate foods and feeding practices should be emphasised and addressed in community health programmes so as to equip primary caregivers with adequate knowledge on child nutrition.

Special consideration should be taken when selecting a study sample so that it can be a true representative of the true population e.g. ethnicity, proportional sampling techniques can be used to ensure representativeness.

These study findings can be disseminated to policy leaders, social departments and other international organisations and later on used to develop strategies that can be used by so as to optimize infant nutrition in regions with high malnutrition prevalence.

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Appendix 1 Ranking of all the 149 food items consumed by the Bt20 participants

Table showing ranking for all the 149 food items consumed by the Bt20 participants

Number	Food items	Number of recordings	%
1	Eggs	391	2.58
2	Gravy	371	2.45
3	Banana	356	2.35
4	Mielmeal-stiff	351	2.32
5	Plain biscuit	349	2.31
6	Orange	341	2.25
7	Mieliemeal	338	2.23
8	Rice	336	2.22
9	Peanut butter	331	2.19
10	Brown bread	329	2.17
11	Average green	324	2.14
12	Mashed potatoes	324	2.14
13	Flavoured yoghurt	317	2.09
14	Apple	311	2.05
15	Minced beef	286	1.89
16	Margarine	2.83	1.87
17	Average yellow	272	1.80
18	Full cream milk	271	1.79
19	Fruit juice	270	1.78
20	Oil	255	1.68
21	Homemade soup	252	1.66
22	Squash	246	1.63
23	Chicken stew	240	1.50
24	Average fruit	233	1.54
25	Other milk types	233	1.54
26	Cooked tomatoes	228	1.51
27	Cheese cheddar	226	1.49
28	Tea	224	1.48
29	Jelly	196	1.29
30	Ice-cream	193	1.27
31	Pork boerewors	185	1.22
32	Fried fish	173	1.14
33	Beef steak	173	1.14
34	Oats	165	1.09
35	Sweet sucking	159	1.05
36	Vienna	159	1.05
37	Raw tomatoes	156	1.03
38	Polony	149	0.98
39	White bread	147	0.97
40	Carbonated beverage with sugar	145	0.96

41	Potato chips	137	0.91
42	Average white	132	0.87
43	Beef stew	129	0.85
44	Cake	127	0.84
45	Boiled potatoes	125	0.83
46	Tomato sauce	123	0.81
47	Pilchards	119	0.79
48	Jam	119	0.79
49	Sugar	111	0.73
50	Other cereals	109	0.72
51	Plain chocolate	108	0.71
52	Plain yoghurt	103	0.68
53	Maltabella	102	0.67
54	Baked beans	95	0.63
55	Butter	95	0.63
56	Roasted chicken	94	0.62
57	Roasted beef	94	0.62
58	Baked potato	88	0.58
59	Bolognaise sausage	79	0.52
60	Crisps	78	0.52
61	Beef meatball	77	0.51
62	Beef spaghetti	76	0.50
63	Mutton chop	75	0.50
64	Jelly	73	0.48
65	Popcorn	72	0.48
66	Mayonnaise	71	0.47
67	Roasted potatoes	68	0.45
68	Mutton stew	67	0.44
69	Dried beans	67	0.44
70	Fresh fish baked	58	0.38
71	Milo	57	0.38
72	Average red	54	0.36
73	Tinned soup	51	0.34
74	Peanut	50	0.33
75	Dried lentils	50	0.33
76	Fish paste	48	0.32
77	Baked pudding	48	0.32
78	Pork sausage roll	47	0.31
79	Tinned fruit	47	0.31
80	Instant pudding	44	0.29
81	Pronutro	44	0.29
82	Salad green	43	0.28
83	Filled biscuits	42	0.28
84	Cream	41	0.27
85	Chicken curry	40	0.26

86	Beef cottage pie	39	0.26
87	Mielierice	38	0.25
88	Gouda	38	0.25
89	Chicken pie	38	0.25
90	Toffee	37	0.24
91	Scones	36	0.24
92	Mutton roast	36	0.24
93	Game isotonic	36	0.24
94	Pork bacon	35	0.23
95	Macaroni cheese	34	0.22
96	Dried prunes mixed	34	0.22
97	Coffee	33	0.22
98	Pork ham	31	0.20
99	Rice krispies	30	0.20
100	Pasta	30	0.20
101	Pork sausage	29	0.19
102	Mielies	28	0.18
103	Weetabix	27	0.18
104	Chocolate bar	26	0.17
105	Bolognaise pie	25	0.17
106	Sardines	25	0.17
107	Samp	25	0.17
108	Custard	24	0.16
109	Cheese sauce	24	0.16
110	Marmite	24	0.16
111	Sweetened cereal	24	0.16
112	Pastry	23	0.15
113	Tart jam	22	0.15
114	Dried raisin	20	0.13
115	Beef curry	20	0.13
116	Carbonated beverage with no sugar	20	0.13
117	White sauce	19	0.13
118	Cream crackers	19	0.13
119	Mustard sauce	18	0.12
120	Chutney sauce	18	0.12
121	Salad dressing	17	0.11
122	Pro-vita	17	0.11
123	Cottage	16	0.11
124	Cocoa	16	0.11
125	Other spread	16	0.11
126	Whole wheat	15	0.10
127	Skimmed milk	15	0.10
128	Pork stew	13	0.09
129	Mutton curry	13	0.09
130	Doughnut	12	0.08

131	Other biscuits	12	0.08
132	Other fruits	12	0.08
133	Milk snack	11	0.07
134	Cornflake cereal	11	0.07
135	Tuna salad	11	0.07
136	Pork chops	11	0.07
137	Low fat milk	11	0.07
138	Roasted pork	8	0.05
139	Pizza	8	0.05
140	Bovril	8	0.05
141	Alb ran	8	0.05
142	Fish pie	7	0.05
143	Other soups	7	0.05
144	Other beverage	4	0.03
145	Other vegetables	3	0.02
146	Horlicks	3	0.02
147	Other snacks	2	0.01
148	Other starch	1	0.01
149	Other sauces	0	0.00
	Total	**15,138**	**100**

Appendix 2 Table showing infant feeding practices among the Bt20 infants.

Variables	Stunting at year one			Stunting at year two		
	Normal Mean (95%CI)	Stunted Mean (95%CI)	P-value	Normal Mean (95%CI)	Stunted Mean (95%CI)	P-value
Ever breastfed (Yes/No)	1.1(0.8-1.3)	0.9(0.9-1.0)	0.75	0.95(0.9-1)	0.96(0.9-1.0)	0.52
Duration of breastfeeding (Months)	12(11.3-12.7)	12(9.8-14.8)	0.81	13.7(13-14)	11.8(10.2-13.3)	**0.02**
Duration of bottle feeding (Months)	0.8(0.75-0.81)	0.8(0.6-0.9)	0.58	0.78(0.74-0.82)	0.78(0.71-0.86)	0.87
Introduction to solids(Years)	0.04(-0.02-0.05)	0.02(-0.02-0.05)	0.4	0.05(0.03-0.07)	0.03(0.006-0.59)	0.34

Variables	Wasting at year one			Wasting at year two		
	Normal Mean (95%CI)	Wasted Mean (95%CI)	P-value	Normal Mean (95%CI)	Wasted Mean (95%CI)	P-value
Ever breastfed(Yes/No)	1.1(0.9-1.3)	0.9(0.8-1.0)	0.74	0.95(0.9-1.0)	0.95(0.9-1.0)	0.95
Duration of breastfeeding(Months)	12(11.4-12.7)	11.1(7.9-14.6)	0.69	13.2(12.5-13.9)	14.8(11.9-17.7)	0.25
Duration of bottle feeding(Months)	0.8(0.75-0.81)	0.7(0.6-0.9)	0.57	0.78(0.74-0.82)	0.74(0.58-0.89)	0.53
Introduction to solids(Years)	0.04(0.02-0.05)	0	0.26	0.04(0.03-0.06)	0.08(-0.01-0.2)	0.35

Underweight

Variables	Underweight at year one			Underweight at year two		
	Normal Mean (95%CI)	Underweight Mean (95%CI)	P-value	Normal Mean (95%CI)	Underweight Mean (95%CI)	P-value
Ever breastfed(Yes/No)	1.1(0.84-1.34)	0.95(0.9-1.0)	0.75	0.95(0.9-1)	0.96(0.9-1.0)	0.52
Duration of breastfeeding(Months)	11.9(11.2-12.6)	13.5(11.3-15.7)	0.18	13.3(12.5-14)	13.3(11.6-14.9)	0.98
Duration of bottle feeding(Months)	0.8(0.75-0.81)	0.76(0.65-0.87)	0.79	0.78(0.74-0.81)	0.79(0.71-0.88)	0.74
Introduction to solids(Months)	0.04(0.02-0.05)	0.01(-0.01-0.04)	0.28	0.05(0.03-0.07)	0.03(0.008-0.06)	0.74

Appendix 3

Appendix 3: A table of comparison between those with dietary data (1,546) and those without dietary data (1,727)

Variable	Those with dietary data	Those without dietary data	Chi-square	P-value
Ethnicity				
Whites	3.6%(56)	8.7%(151)		
Blacks	84.8%(1,311)	72.8%(1,257)	74.8	**0.0001**
Asians	2.5%(38)	4.5%(77)		
Mixed ancestral	9.1%(141)	14%(242)		
Birth weight				
Less than 2500gms	10.3%(159)	11.2%(193)		
2500-4000gms	87.5%(1,352)	85.9%(1,484)	3.75	0.29
4001-4800gms	2%(31)	2.8%(48)		
Missing	0.3%(4)	0.1%(2)		
Parity				
One	61.9%(958)	64.7%(1,117)	2.6	0.10
Two or more	38%(588)	35.3%(610)		
Gender				
Boys	49%(759)	48.2%(832)	4.6	0.2

Girls	50.9% (787)	51.8%(895)		
Maternal age				
13-19	57.9% (896)	59.5%(974)		
20-29	15.7% (242)	14%(242)	37.02	**0.0001**
30-39	24.6%(381)	27.5%(475)		
40-50	1.75%(27)	1.9%(34)		
Marital status				
Separated/divorced	37.9%(587)	48.6%(828)	1.9	0.16
Married/living	62%(959)	51.4%(877)		
Maternal education				
No formal	85.4%(1,312)	83.5%(1,165)	1.96	0.16
Post training	14.6%(225)	16.5%(230)		
House ownership				
Rental local	49.2%(755)	46.5%(573)		
Owned /Rented	50.8%(780)	53.5%(659)		
House type category			542.3	**0.0001**
Shack/flat/hostel	29.1%(503)	24.6%(381)		
House/cottage	43.3%(748)	74.7%(1,155)		
Missing	0.65%(10)	27.6%(476)		

Gestation age				
Preterm	22.9%(342)	22.2%(372)	0.21	0.65
Normal	77.1%(1,153)	77.8%(1,304)		

Appendix 4: A table showing comparison between those with complete data (683) and those with missing data on growth at age two (456).

Variables	Those with all the data	Those without growth data at age 2	Chi-square	P-value
Ethnicity				
Whites	46 (82.1%)	10 (17.9%)		
Blacks	552 (60%)	369 (40%)	19.2	**0.001**
Asians	8 (33%)	16 (67%)		
Colored	77 (55.8%)	61 (44.2%)		
Birthweight				
2500-5000grams	621 (60.1%)	411 (39.8%)	0.47	0.49
<2500grams	59 (56.7%)	45 (43.3%)		
Parity				
One	278 (61.9%)	171 (38.1%)	1.17	0.28
Two or more	405 (58.7%)	285 (41.3%)		
Gender				
Boys	335 (61.1%)	213 (38.9%)	0.59	0.44
Girls	405 (58.7%)	243 (41.1%)		

Maternal age				
13-19	107 (58.8%)	75 (41.2%)	0.98	0.81
20-29	385 (59.7%)	260 (40.3%)		
30-39	179 (60.7%)	116 (39.3%)		
40-50	12 (60.7%)	5 (29.4%)		
Marital status				
Separated/divorced	420 (60.2%)	278 (39.8%)	0.032	0.86
Married/living	263 (59.6%)	178 (40.4%)		
Maternal education				
No formal education	78 (56.5%)	60 (43.5%)		
Std 8/std 9-10	512 (60.3%)	337 (39.7%)	0.97	0.61
Post training	93 (62%)	57 (38%)		
House type category				
Shack/flat/hostel	132 (50.2%)	131 (49.8%)	16.9	**0.001**
House/cottage	551 (63%)	323 (36.9%)		
House ownership				
Rental local authority	333 (61.2%)	211 (38.8%)	5.02	0.08

Owned/Rented	350 (59.1%)	242 (40.9%)

Appendix 5 : Food frequency questionnaire used in the BTT

Appendix 6: Ethics clearance certificate for this study